POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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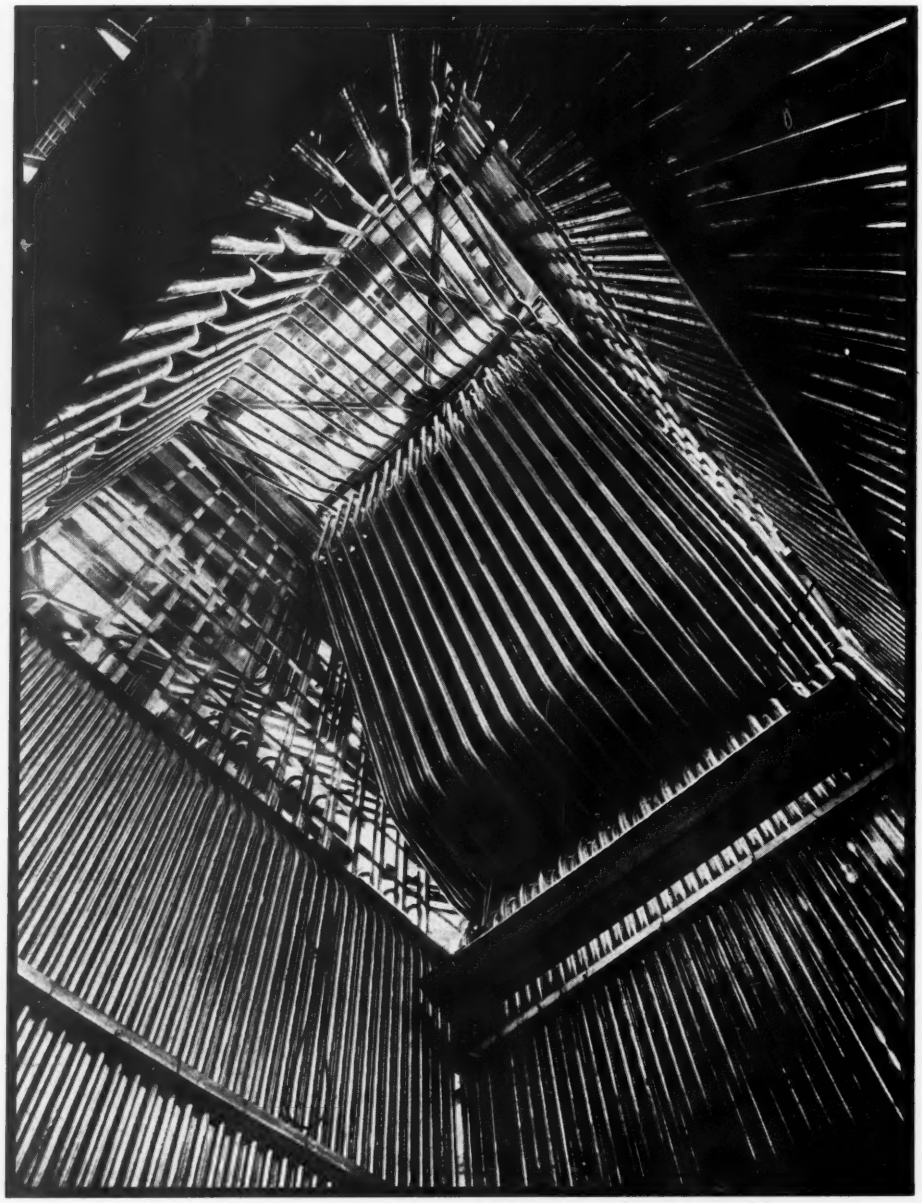


A STUDY in TUBE TECHNIQUE

WE HAVE CALLED this a study in tube technique; an artist might refer to it as a good example of "functional design" but whatever one calls it, it remains an interesting boiler picture. It is a view looking straight up into the furnace of the 250,000 lb. per hr. steam generator at Rochester. Wonder what James Watt would say if he could come back and look at it? Most likely he would not say anything for, probably, he would be rendered speechless upon being informed that this was the consequence of his tea kettle idea. ¶ It is a far cry from James Watt's boiler to this complex affair of alloy steel with its intricate system of control but it would be irrational to assume that this is final or even that this general form of boiler will remain. Interesting experimental work with steam generators of radically different designs are being conducted in various countries and it is quite possible that the boiler of the future will be as different from this one as this one is different from James Watt's. From a present day standpoint, however, this boiler leaves little to be desired.

With the Editors

The Mysteries of Sliding Contacts

THE BRUSH PROBLEM described on page 234 of this issue illustrates the importance of at least one factor in connection with brush operation which has long been known but which until recently has never been quite understood; that is, the chocolate brown color of the commutator. All operators of direct current machinery for years have taken pride in the chocolate brown color of their commutators, it is always pointed to as an illustration of good operation—of a machine which commutates well and has little or no sparking.

Just why a chocolate brown color should make for better commutation than another color was something which had never fully been disclosed. It was suspected that the color was due to a film of oxide, but this does not explain the matter.

Recently, however, there has been a considerable amount of investigation into the nature of sliding contact phenomena and these all indicate that the electrical characteristics of any ordinary sliding contact are dependent upon the oxide film on the surface of the slip ring or commutator.

In a paper recently presented before the American Institute of Electrical Engineers, R. M. Baker gave the results of some interesting experiments in this field. Since the most outstanding characteristics of sliding contacts is the change in contact resistance with current, this fact was used to test the idea that the contact resistance of a sliding contact between a brush and a rotating slip ring is governed by the existence of an oxide film on the surface of the ring and the process by which this film is broken down or repaired as the current through the contact changes.

It seems that when a sliding contact is carrying low current, the oxide film on the ring is practically continuous and serves to insulate the brush rather effectively from the ring. When the current suddenly is increased, voltage will appear across some spots in the oxide film of sufficient magnitude to break down this film in much the same manner as any thin layer of poor insulation is broken down. The breakdown is associated with considerable heat, and metallic bridges will be found in the oxide film. If the original bridges are not large enough to carry the current without melting, they will grow, possibly by reducing the oxide in their neighborhood until bridges of sufficient cross section exist to carry the current of the contact. As the melting voltage for copper is only 0.45 v., the process need not require a high breakdown voltage. It is necessary only to get the bridges started, and weak spots in the film, especially with the help of the abrasive action of the brush, will take care of this.

The picture of a sliding contact thus, according to Mr. Baker, becomes rather complicated. The brush and ring make mechanical contact over only a fraction of a per cent of the polished brush face because of the inherent lack of smoothness in the contacting surfaces and even then at the points of mechanical contact the brush and the ring are separated by a semi-insulating oxide film which in turn is broken down more or less completely depending upon the amount of current through the contact.

When operating in non-oxidizable atmospheres such as hydrogen and nitrogen, the contact resistance at very low currents was hardly twice that at the highest current. In air the ratio would be several thousand to one.

Since copper oxidizes rapidly in air, it is impossible to operate a commutator or slip ring under ordinary conditions without a coating of oxide on its surface. It would be better if this oxide film were not present, but if it must be, at least it should be uniform.

These experiments cannot fail to impress one with the importance of research into even the most ordinary phenomena. Offhand, nothing could be simpler than a sliding contact and one would scarcely expect it to involve deep fundamental electrical and chemical theory. But as in the case of other simple things, the circuit breaker for example, investigation of a more fundamental nature discloses a complex phenomena which perhaps can only properly be solved by a logical approach from an electronic viewpoint.

Just how the oxide film breaks down is not definitely known but the process of breakdown is probably through the building of metallic bridges out through the oxide.

Liquid films, it has been found, can affect contact drop directly only when these films are of oil or some other liquid having a low vapor pressure. Water films probably produce a very desirable lubricating effect in a sliding contact but do not tend to raise the brush off the ring and therefore do not raise the contact resistance. The water films which lubricate are thin in comparison with the unevenness in the contact and extremely tough. The current, it seems, flows through these thin films with no appreciable loss in voltage.

We direct attention to these facts because the sliding contact has for many years been a very important thing in the operation of electrical machinery, especially direct current machinery. Much still remains to be done but gradually we are beginning to realize "what it is all about." Only a few years ago the arc which formed at the contacts of a switch which opened was considered of no earthly use—merely a detriment. Today, due to Slepian, the arc has been shown to be a necessary influence and when brought under control actually improves the action of the switch.

Only by removing these mysteries, one by one, in a scientific and logical manner can we hope to attain perfection in the design and operation of electrical equipment.

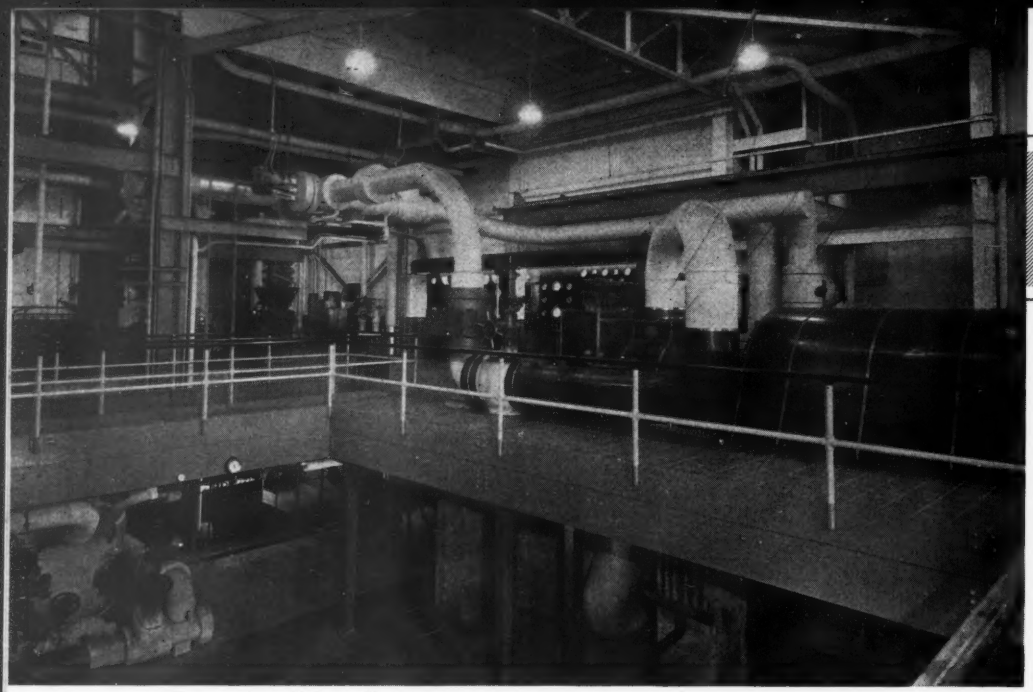


Fig. 1. General appearance of operating room. The 250,000 lb. steam generating unit is at the left; the 6000 kw. turbine at the right and the control board in the central background. Note method of anchoring steam line

New

New 6000 kw. High Pressure Extension to Station No. 3 of the Rochester Gas & Electric Corp. Incorporates Complete Automatic and Centralized Control System

A SIGNIFICANT TREND IN PRESENT day power station practice, though a logical consequence of the recent advances in high pressure technique, is the increasing adoption of the so-called "top" plant idea; i.e., the superposition of a high pressure boiler and turbine on an existing lower pressure plant or system. This makes possible the realization of the high thermal efficiency of the high pressure steam cycle without the necessity of scrapping less efficient but otherwise good existing equipment.

There are many plants in existence today in which the generating equipment is in excellent operating condition and still good for years of service but which, in view of the greater efficiency of modern high pressure equipment, is obsolete from a thermal standpoint. By the addition of high pressure boilers and turbines, however, so arranged as to exhaust into the existing steam system, stations of this type can be improved so as to give thermal efficiencies which compare favorably with the best high pressure practice of today.

Several such "top" units have been built in recent years and at the present time a number of others are in course of development. The most recent actual development of this kind is that made by the Rochester Gas & Electric Corporation in their 1935 extension to Station No. 3 in Rochester.

This extension involved the construction of a new building containing a complete new high pressure steam electric generating plant consisting of a 6000 kw. turbo-generator and a 250,000 lb. per hr. pulverized coal-fired boiler operating at 650 lb. steam pressure. The plant was built during 1935 and it went into operation immediately after the first of this year.

Although not a large plant in terms of electric generating capacity, it is an extremely interesting plant from an engineering standpoint, not only because of its relationship to the old low pressure plant but because of the high excellence of its design. This station is one of the most completely automatic and centrally controlled steam plants that has yet been built. Practically the entire control of the station is centralized in a single position but the operation itself is, for the greater part, automatic, the attendants' duties being chiefly those of a supervisory nature.

Station No. 3, of which this new plant is an extension, is one of a number of generating stations, steam and hydro, which the Rochester Gas & Electric Corporation operates in the vicinity of Rochester, this particular plant being located in Rochester itself. The station dates back some 35 years and has a total generating capacity of around 65,000 kv-a. The new high pressure plant, however, was designed to operate specifically in conjunction with only two units in the old plant, units Nos. 7 and 4. These units operate on steam at 200 lb. gage and a temperature of 530 deg. at the throttle. Combined, these units have a capacity of around 17,000 kw. and a steam consumption of around 220,000 lb. per hr. These units were of course supplied with steam from the old boiler plant operating at about 200 lb. pressure.

The design of the new high pressure plant was based upon the steam requirements of these old units. What was necessary was a high pressure turbine which would deliver at the exhaust, some 220,000 lb. of steam at 200 lb. pressure and at a temperature of around 530 deg.

The turbine selected meets these requirements very closely. It is a 6000 kw. unit, designed for a steam pressure of 650 lb. gage, 750 deg. F. total temperature and the exhaust conditions at full load are about 210 lb., 530 deg. F. with a total steam flow of some 230,000 lb. per hr.

This unit is supplied by a steam generating unit

"TOP" Plant *for* Rochester

fired by pulverized coal and designed for a maximum of 250,000 lb. of steam per hr. at 660 lb. per sq. in. gage.

Essentially then the new high pressure station consists of one boiler and one high back pressure turbo-generator, generating 6000 kw. of electrical energy and supplying some 230,000 lb. of steam at 200 lb. pressure to units 7 and 4 in the old plant. Before passing to the old plant the exhaust from the high pressure turbine passes through a desuperheater so as to avoid excessive temperature of the steam going to the low pressure turbines when the high pressure turbine is operated at low loads. According to the guaranteed performance, the turbine when operating at 6000 kw. has an exhaust temperature of 534 deg. but at 1500 kw., the exhaust temperature is 590 deg., hence the necessity for means of desuperheating. The desuperheater is also required to reduce the temperature of the steam which is by-passed through a 6 in. reducing valve when the high pressure turbine is shut down. In the latter case the steam temperature has to be reduced from about 710 deg. to 525 deg.

Although the present building contains only one boiler and turbine, space has been provided for an additional future turbine and the building is designed so that it can be extended to incorporate another boiler.

General Arrangement

The general arrangement of the equipment is best understood from the plans and elevations shown herewith. As will be apparent, the arrangement is simple, logical and there is ample space around all equipment for safe and convenient operation and maintenance. To a considerable extent, the form of the building was dictated by the design of the boiler which, as can be seen, is a tall affair. As a consequence the building is correspondingly vertical in its general aspect.

The plant is built as a single unit, there being no separate boiler and turbine rooms. Both boiler and turbine are located in the same room and the main operating board is located so that a full view is had of both boiler and turbine. The operating room is roomy, neat and attractive in its general appearance. The walls are of cinder block, painted white, the operating floor of red tile. The boiler casing is finished in aluminum paint. That part of the room containing the turbine is served by a 15 t. overhead crane. A small crane is also provided over the feed pumps which are located alongside of the boilers. A combination freight and passenger elevator gives convenient access to the various floor levels.

The main control board is attractively designed and equipped with an effective system of illumination. An electrically operated annunciator board on the wall above the turbine has a large indicator showing the load in megawatts, as well as high and low pressure steam indicators and 24 translucent glass indicators which light up in case of trouble on any major piece of equipment in the station.

The main turbo-generator, despite its rating of 6000 kw., is small in its physical dimensions, and in order to avoid stresses on the turbine casing from the heavy pipe connections, a specially designed flexible arrangement of pipe is provided. The inlet pipe line is first rigidly fastened to the foundation and from there a small loop connects to the turbine steam chest. Provision for expansion of the exhaust pipe connected to the desuperheater is made by placing the desuperheater on roller supports. To minimize danger from oil fires, all oil piping is located on one side of the turbine and all high pressure steam piping on the other.

The building itself is interesting because it is constructed of cinder blocks, that is blocks made of a mixture of concrete and cinders. With the exception of the water softener and the electrostatic precipitator which is enclosed in a steel casing above the roof, all equipment is contained in the building. The water softener is mounted outside of the building proper on

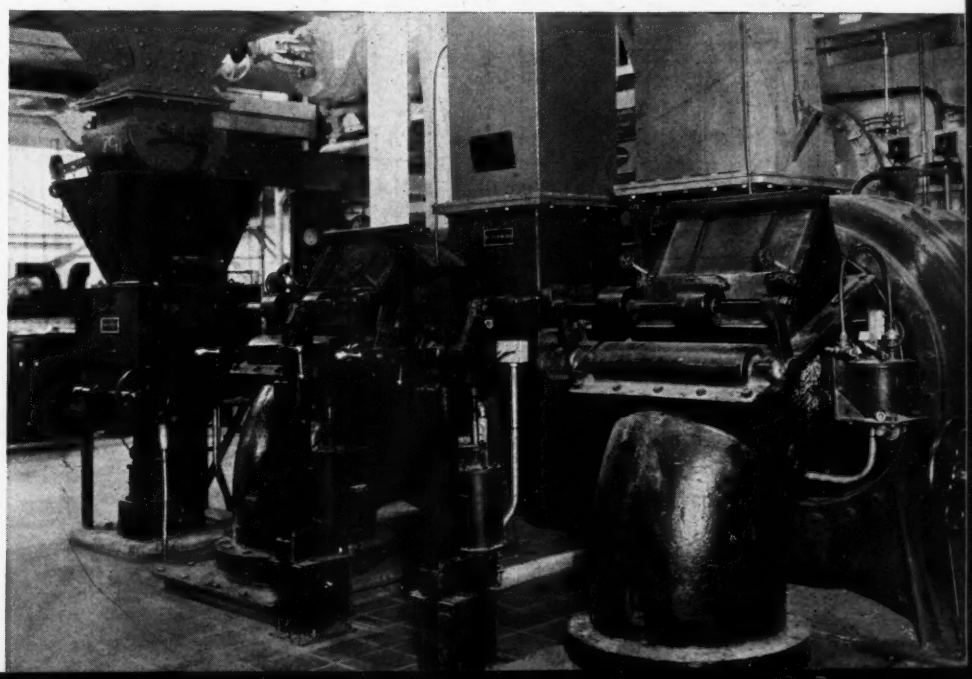


Fig. 2. The exhauster units showing automatic control actuating mechanism. The vibrating feeder is at the extreme left. These are controlled electrically from the air operated mechanism in the foreground

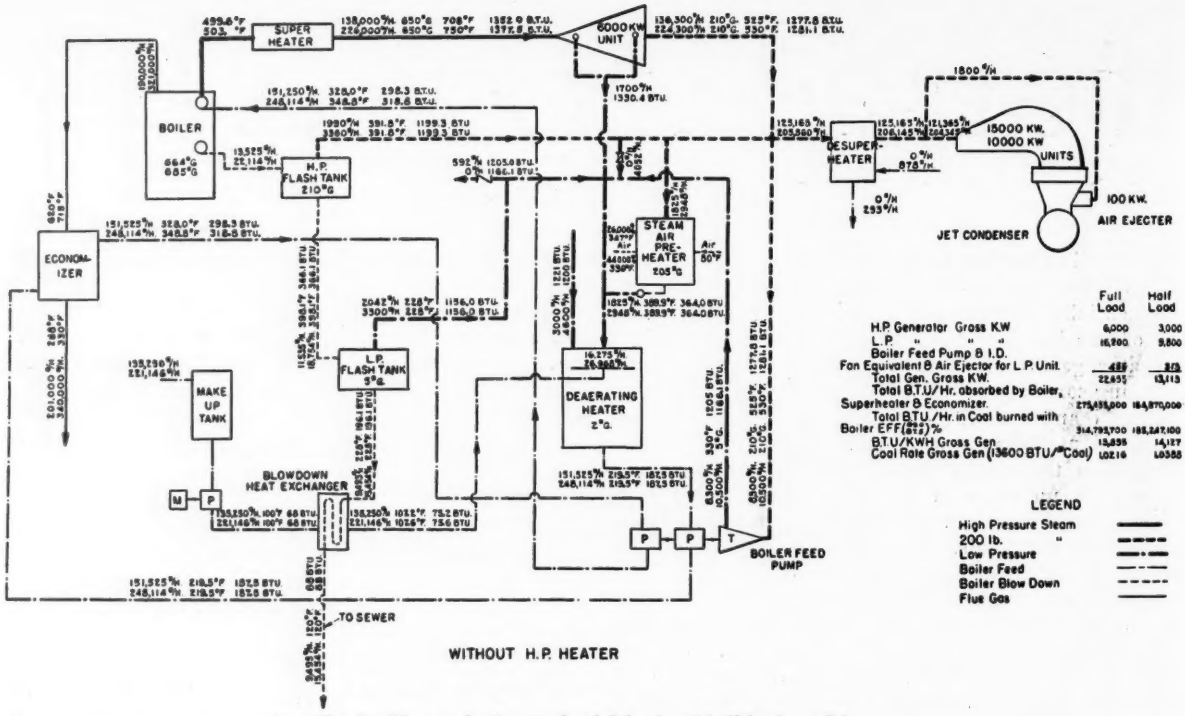


Fig. 3. Heat cycle diagram for full load and half load condition

a steel platform and partially enclosed as to valves and piping, by a corrugated steel enclosure.

The new building is located immediately adjacent to the old boiler house and for the present time makes use of one of the existing stacks. A horizontal breeching on the outside of the building carries the gases from the new boiler to the stack of the existing boiler plant.

The general character of the system involved in this station may be most easily understood by referring to the heat cycle diagram in Fig. 3. Water, it will be noted, enters the system from the makeup tank from which it is drawn by a small pump and delivered to the deaerating heater after first picking up some seven degrees of heat in the blow down heat exchanger. From the deaerating heater, the water passes to the primary feed pump which delivers it to the economizer. From the economizer it is drawn into the secondary feed pump which delivers directly to the boiler.

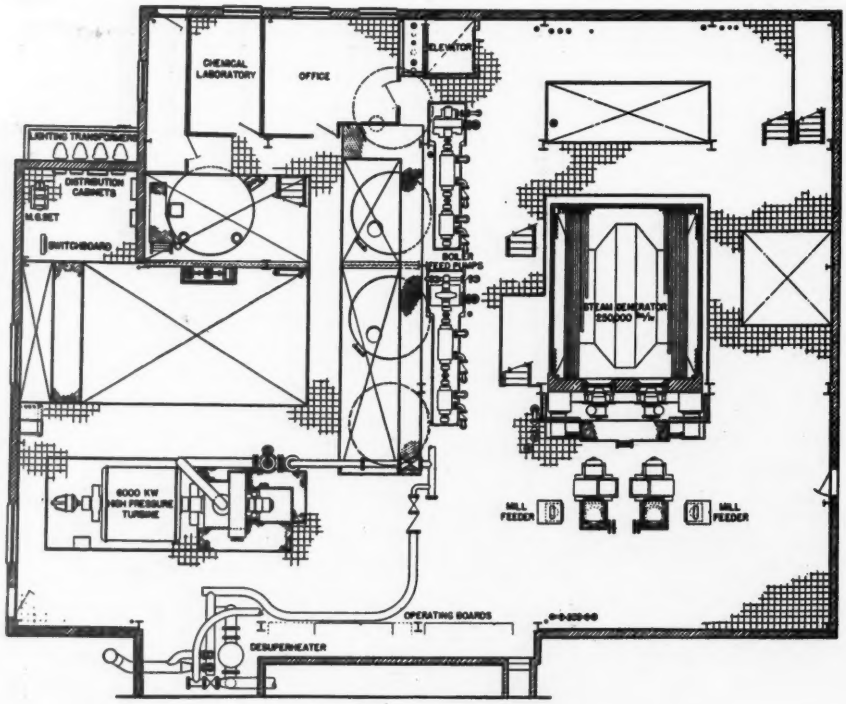


Fig. 4. Plan of operating floor

The steam leaving the boiler and superheater at a pressure of 650 lb. and a temperature of around 725 deg. is sent directly into the 6000 kw. high pressure turbine from which it exhausts at a pressure of 200 lb. The greater part—205,560 lb. per hr. at full load—of this 200 lb. steam passes through the desuperheater to the low pressure turbines.

Two hundred pound steam also goes to the steam air preheater, and to the boiler feed pump turbines as shown. Blow down from the boiler passes first through the high pressure flash tank, then through the low pressure flash tank and finally through a blow down heat exchanger to the sewer.

Coal is delivered by trucks into a receiving hopper located adjacent to the old boiler house and reduced to proper size by a hammer-mill type of crusher, if necessary, or the crusher can be by-passed. A bucket elevator carries the coal upward to a point above the hop of the coal bunker where it is discharged to one end of a belt conveyor. The elevator is supported by a structural steel tower, the upper portion of which is enclosed by Robertson protected metal. The belt conveyor receiving coal from the bucket elevator extends from the elevator tower, over the space required for future bunkers (outside of the present building) to the upper part of the present bunker where it is discharged through a movable tripper into the 500 t. raw coal overhead bunker shown in the elevations herewith. The equipment is designed to handle run-of-mine coal from western Pennsylvania through the feeder and crusher at the rate of 125 t. per hr. From the crusher to the bunkers the equipment will handle 125 t. per hr., 100 per cent of which will pass through a 1¼ in. ring.

Coal Handling and Firing Equipment

This coal handling equipment is electrically interlocked by means of auxiliary switches on the main circuit breakers, an auxiliary switch operated by the by-pass or "flapper" gate on the coal crusher chute and a centrifugal switch on the coal crusher. Under normal conditions, the equipment can be started in the following sequence: 1, flight conveyor; 2, elevator; 3, crusher; 4, apron conveyor. Failure of No. 1 will stop Nos. 3 and 4. Failure of No. 2 will stop Nos. 3 and 4. Failure of No. 3 will stop No. 4.

From the raw coal bunker the course followed by the coal is evident from the accompanying elevations of the station. It is delivered from the bottom of the bunkers through the duplex bunker gates, 18 in. sq., into two receiving hoppers above the feeders. The feeders are of the Jeffrey vibrating type, allowing feeding rates from zero to full rating by simply varying the current through the integral vibrating motors by Variacs. The latter are small adjustable transformes controlled automatically from the combustion control system as will be described later. Each feed includes three vibrating units. From the feeders the coal passes through the coal spouts into the pulverizing mills.

The pulverizing mills are Tricone Ball Mills of the air-swept type with constant coal level within the pulverizer maintained by a controller actuating the coal feeder. The output of the mill is controlled independently of the feed rates by varying the air flow through the mill. Oversized material rejected in the classifier, which has been dried by its passage through

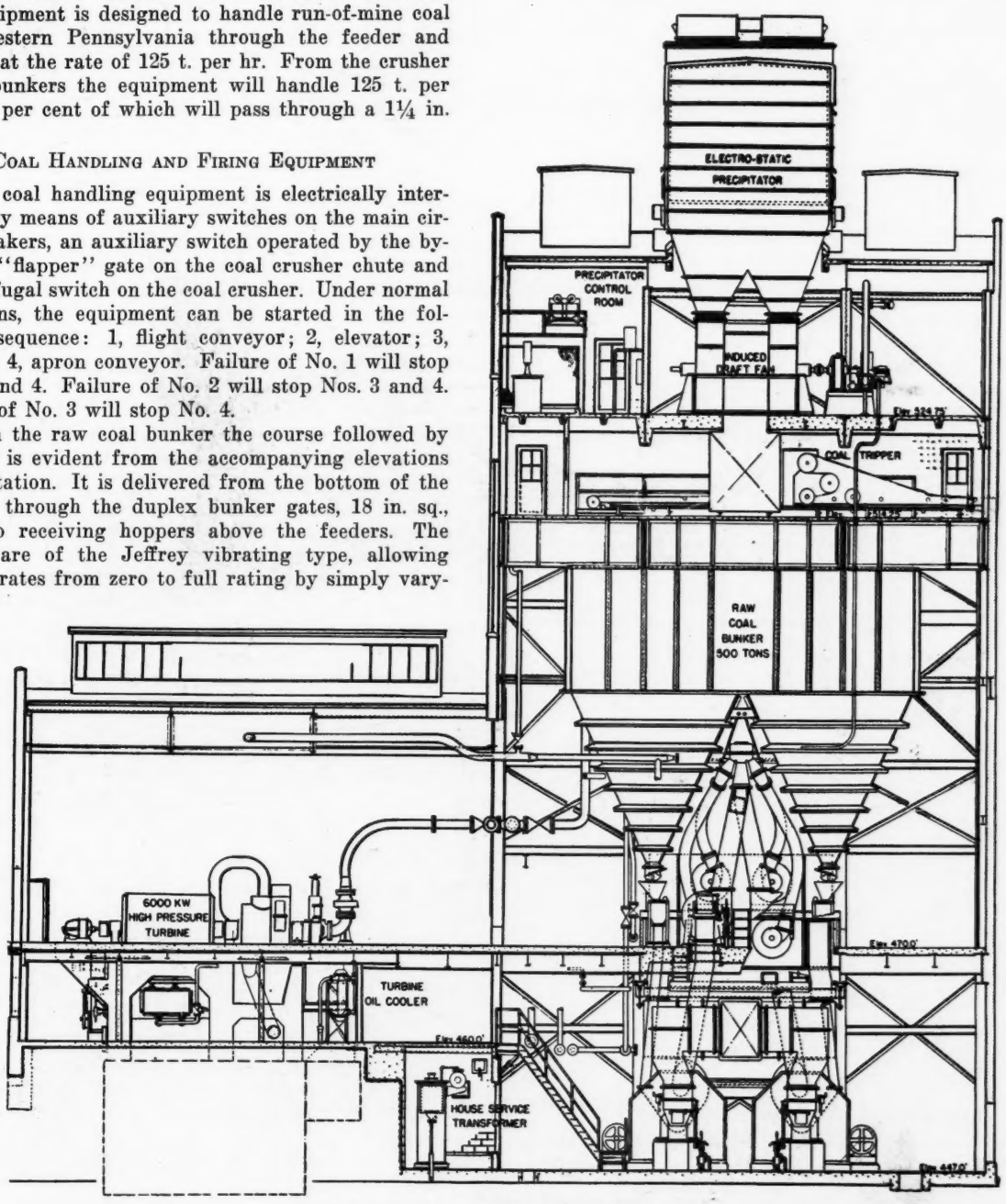


Fig. 5. Elevation of boiler and turbine room

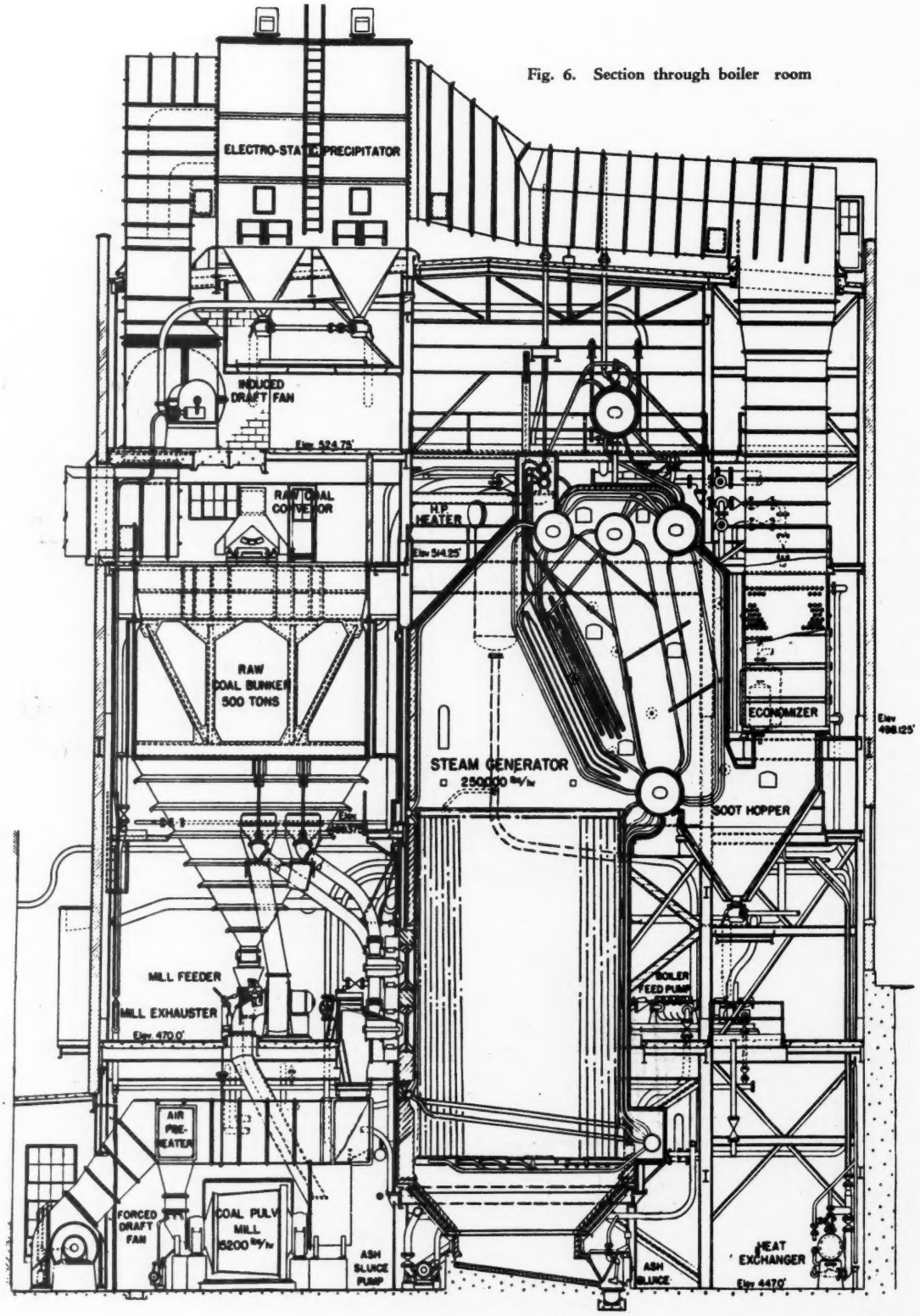


Fig. 6. Section through boiler room

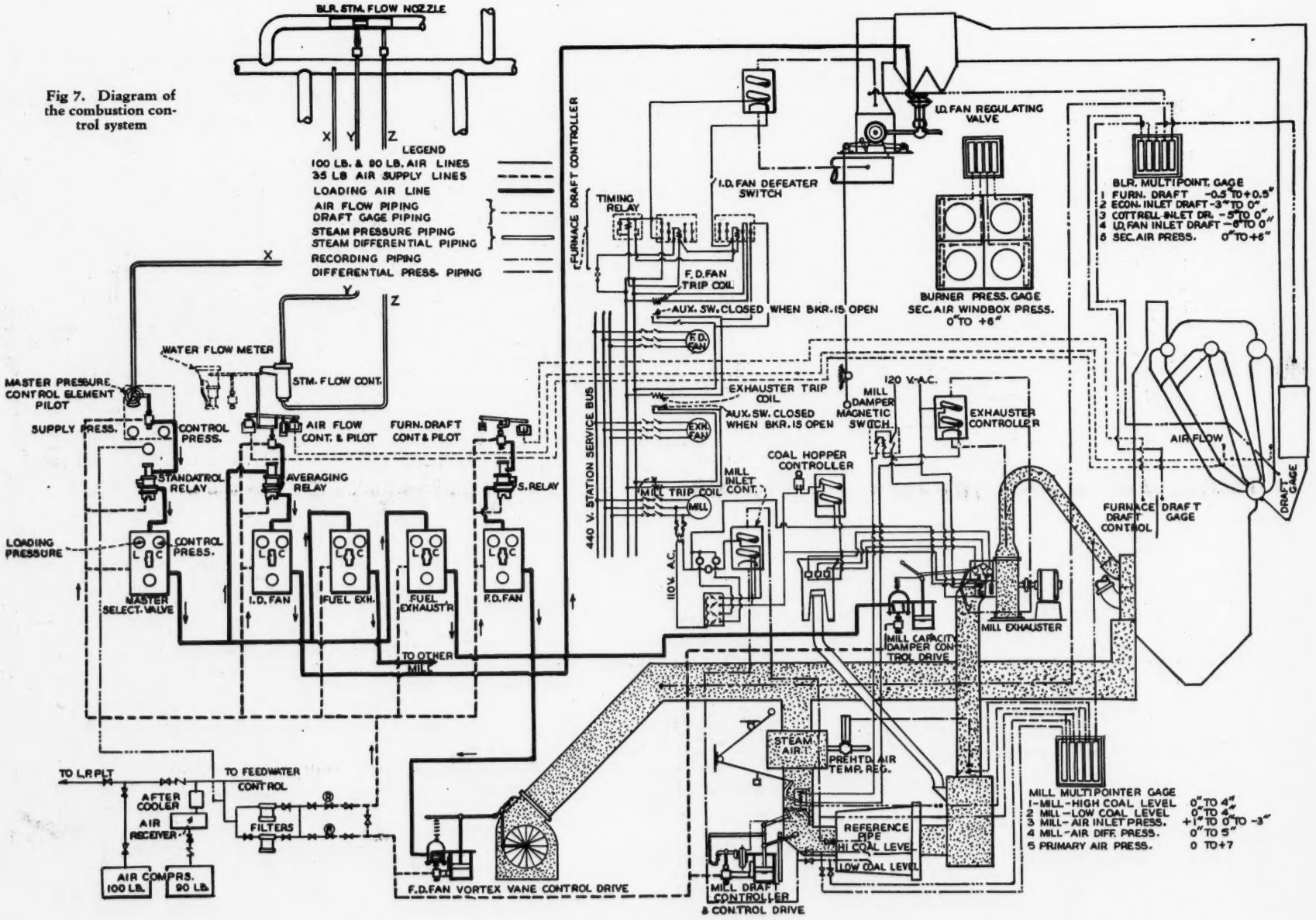


Fig 7. Diagram of the combustion control system

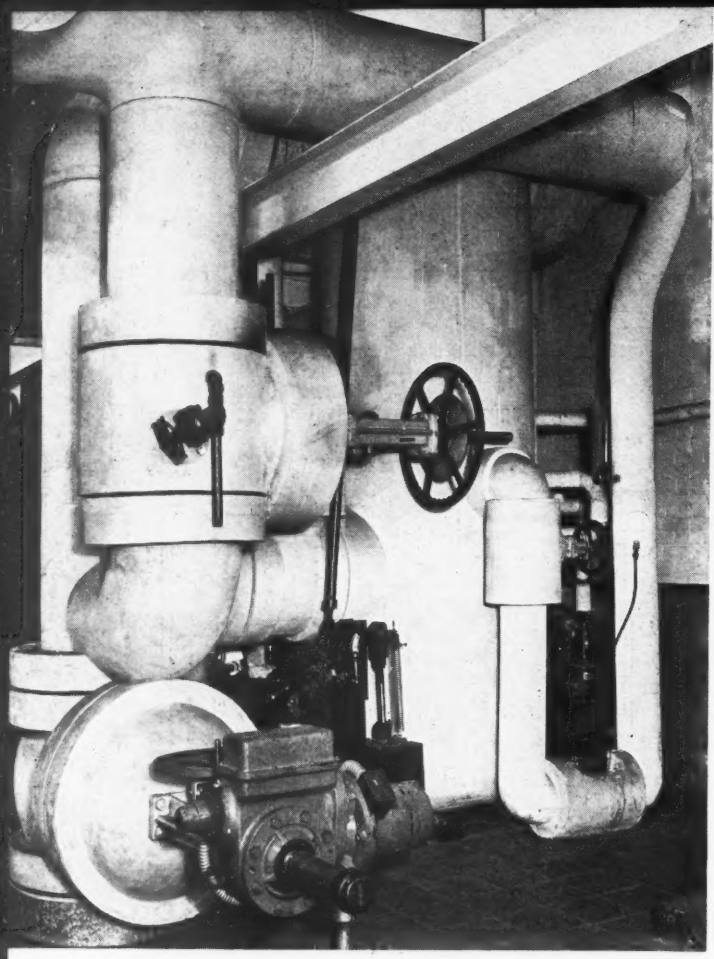


Fig. 8. The desuperheater, showing mechanism for automatic control of the butterfly valve

the mill, is mixed with the incoming feed before it enters the mills and partly absorbs the surface moisture of the fresh coal.

From each mill the pulverized coal and air pass through an exhauster to a distributor which divides the coal to two spouts supplying one burner each in the boiler front wall, or a total of four burners with two pulverizers.

Steam Generating Equipment

In the design studies an analysis of the various heat cycles indicated the most economical installation to be one in which the air for combustion is heated by a steam type air heater. Accordingly, the steam generating equipment consists of a boiler, superheater and an economizer together with a steam air preheater.

The boiler is a 4 drum, 15,300 sq. ft. bent tube boiler designed for a maximum of 250,000 lb. of steam per hour at 660 lb. pressure. It is provided with a completely water-cooled furnace with De Wolf refractory construction and insulated with 3 in. of rock wool all around. The outside casing is of steel plate.

A "fifth" washer drum is an interesting feature of this installation. This drum is located directly above the boiler and its function is to deliver steam with not more than 5 p.p.m. of solid matter when the water contains as much as 3000 p.p.m. of salts. The feedwater to the boiler is introduced into this drum. By means of a unique arrangement of baffles and sprays the feedwater is passed through the steam, after which it (the water) passes on to the boiler. The steam leaving the washer drum passes directly into the superheater and out to the main high pressure header to the turbine.

The furnace has four burners all in the front wall, as shown on the drawings. A ventilated cast iron furnace bottom is provided with two hoppers and ash is removed by means of a Hydrojet Ash sluicing system. The ash transport trench is made up of 18 in. wide nickel cast iron liners in a concrete trench. The trench has three transport nozzles supplied with water at 100 lb. pressure for removing the ash. Soot deposited in the economizer hopper and the precipitator hopper is removed by an A-S-H hydrovac system.

The continuous blow off system consists of a 2 in. forged steel needle control valve, high and low pressure flash tanks and a heat exchanger. In the high pressure flash tank, part of the concentrate is flashed at 210 lb. gage into steam which passes into the 210 lb. system. The remaining concentrate is drained through an external drainer into the low pressure flash tank where the steam flashed at 5 lb. gage pressure is piped into the deaerating heater and the concentrate drained directly into the heat exchanger with a loop seal formed by the outlet of the heat exchanger.

Feedwater System

The course of the feedwater has already been described briefly. From the make up tank, a motor driven pump delivers it to a 32,000 g.p.h. deaerating type, hot process water softener, consisting of a sedimentation tank together with feeding equipment for chemicals, phosphate and sodium sulphate, filters and wash water pumps.

Two boiler feed pumps are installed, each consisting of a 3-stage primary pump and a 5-stage secondary pump mounted on a common sub-base which also carries the driving turbines. The two pumps of each unit are coupled together with the secondary pump next to the driving turbine.

The primary pump takes water from the deaerating heater at 212 to 220 deg. and pumps it through the economizer. From the economizer it goes to the secondary pump at about 390 deg. which discharges into the boiler.

Both feed pumps are driven by 450 hp., 3450 r.p.m. non-condensing turbines operated at 210 lb. steam inlet pressure, 525 deg. F. and with 5 lbs. back pressure. The pumps are regulated by means of automatically controlled regulating valves in the steam supply lines to the turbine as will be described in detail below.

Desuperheater

The desuperheater installed to limit the temperature of the steam going to the low pressure turbines when the high pressure turbine is operated at low loads or when steam is by-passed through a reducing valve from the high pressure main, is a Blaw-Knox unit, or ductiwelded construction, 36 in. in diameter and 13 ft. overall height. The arrangement of turbine, reducing valve and desuperheater is shown in the drawing, Fig. 11. The regulation of the final temperature of steam leaving the desuperheater is obtained by passing part of the steam through water in the lower part of the desuperheater.

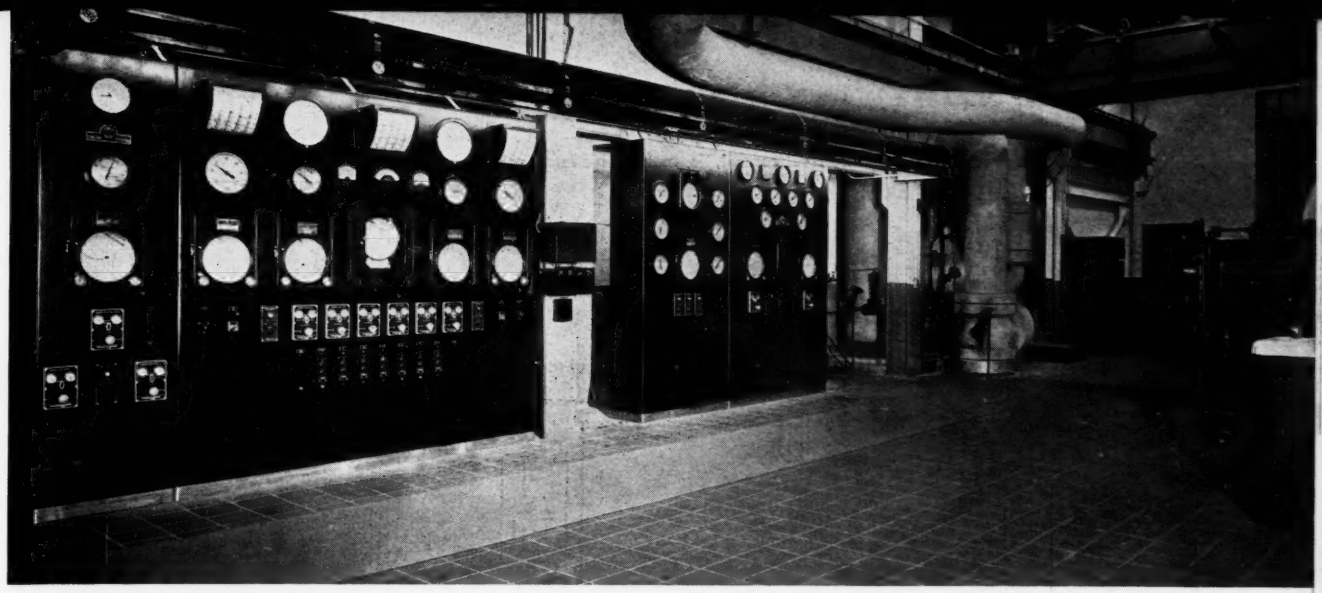


Fig. 9. Control of entire station is centralized in these panels. (Photo, Bailey Meter Co.)

The saturated steam after passing through elimination plates then mixes with the superheated steam passing directly through the upper part of the desuperheater. To insure uniform steam at the outlet of the desuperheater a thorough mixing of the saturated and superheated steam is assured by a helical plate in the outlet steam nozzle, giving the steam a whirling motion.

The steam by-passed through the desuperheater is controlled by the position of a 16 in. butterfly valve in the 16 in. main steam line which is regulated automatically through a temperature control device in the superheater exhaust line.

The feedwater for desuperheating the steam in the desuperheater is supplied directly from the economizer through a feed regulating valve. It was found that the pressure of the feedwater supplied from the economizer was sufficient for the desuperheater but a tap on the first stage volute of the secondary boiler feed pump also is provided which can supply feedwater at about 175 lb. higher pressure.

Feedwater supply is regulated so that a constant water level is maintained in the desuperheater. In order to keep down the concentration in the desuperheater a blowdown of 50 per cent of the water evaporated is provided for. For use in case of emergency, the desuperheater is also connected to the feedwater supply from the old plant at about 260 lb. pressure. Each of these sources are level controlled by thermo-hydraulic generators with metal bellows-operated regulator valves. The blowdown is controlled by a hand regulated "Flocontrol" valve.

Control of Equipment

The control features of this station, as indicated in the introductory paragraphs, are most complete and almost entirely automatic. The control is centered in the operating board which is arranged along one wall in full view of both turbine and boilers. All major operations are controlled from this position.

In general the control system may be divided into two parts: first, that which has to do with the combustion and fuel supply equipment and second, that involving feedwater level, excess pressure, pressure reducing valve operation and desuperheater temperature and level. At some points these two systems of control overlap and at these points they are coördinated but in general the two systems can be regarded as being separate. In each instance the Bailey System of control is used.

The combustion control diagram is shown in Fig. 7; the feedwater level, steam pressure and temperature and desuperheater control in Fig. 11.

In order to have a stable control of the steam generating equipment, the rate of combustion must be regulated in accordance with the demand on the boiler as indicated by the steam pressure. Any control must, therefore, regulate the rate of combustion in such a way that the steam pressure at a given point is kept substantially constant. In order to maintain the highest efficiency at any load, a correct ratio of excess air to

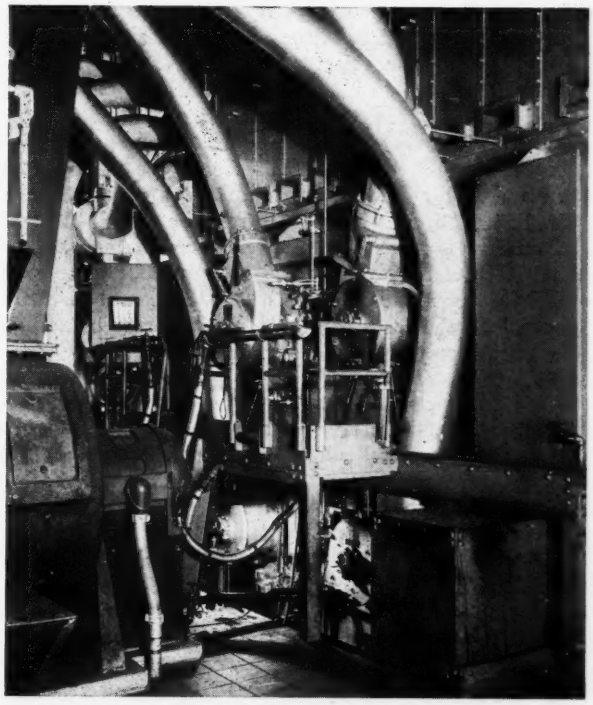
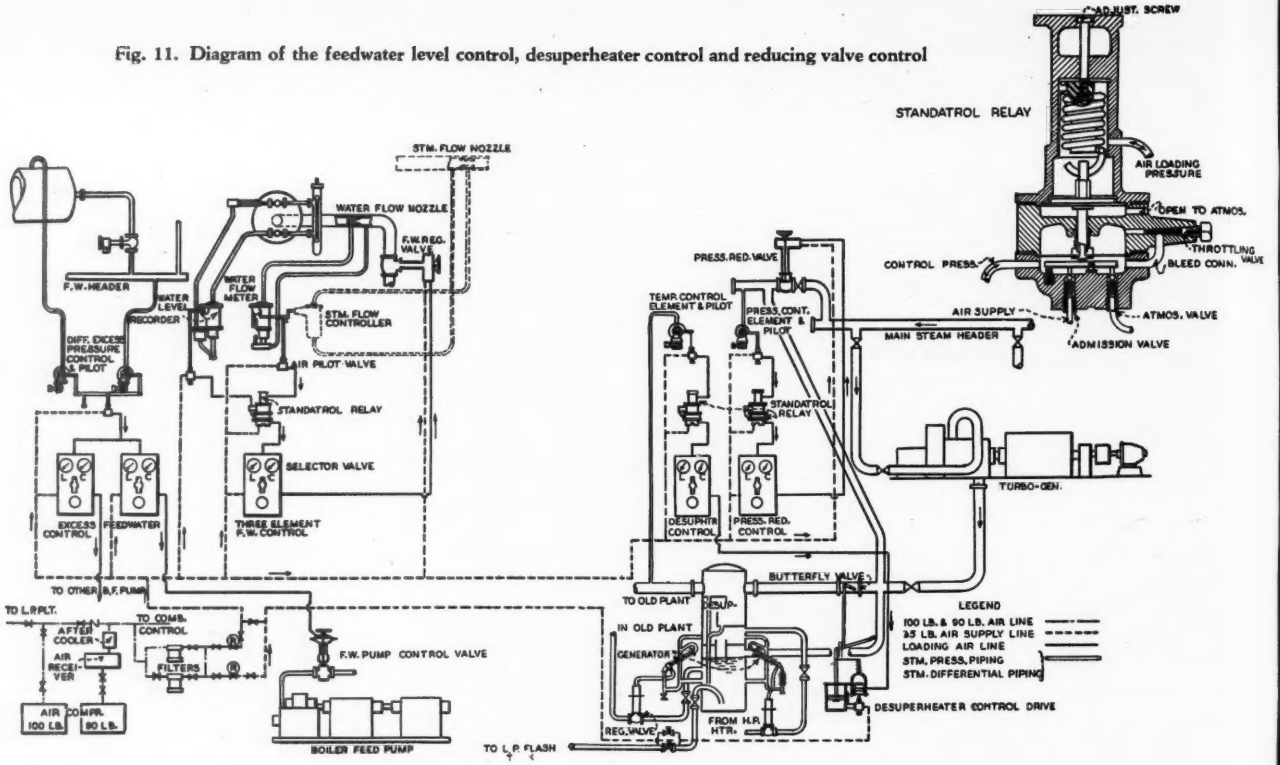


Fig. 10. Close up of the burners

Fig. 11. Diagram of the feedwater level control, desuperheater control and reducing valve control



fuel rate must be maintained. In the Bailey control system this is accomplished by keeping the steam flow-air flow in the correct relation. The regulation of the different equipment is obtained through a compressed air system operating pilot valves and control valves.

A master steam pressure controller on the master panel regulates the pressure of the compressed air to the control system through a master air pilot and a Standatrol relay. The air to the control system passes through a master selector valve on the same panel which, according to its position, allows automatic control by steam pressure or hand control.

A steam flow mechanism on the boiler panel records the steam flow through an orifice in the main steam line and an air flow mechanism, the draft loss through the boiler. Since the correct relation of air flow to steam flow is the basis for efficient combustion at any load, the steam flow-air flow mechanism is, therefore, used to adjust the pressure of the compressed air for control of the induced draft fan to that controlling the fuel supply set by steam pressure.

Flexibility

Primarily, therefore, the steam pressure through a master pressure controller, determines the compressed air pressure regulating the fuel supply and, secondarily, the steam flow-air flow mechanism, adjusts the compressed air pressure controlling the speed of the turbine driven induced draft fan for a given load. The forced draft fan as will be noted from Fig. 7, is regulated by the pressure in the furnace which is maintained constant. These are the principal features of the control system. It is entirely automatic, but selector valves on the master and boiler panels are inserted in the compressed air control lines whereby the automatic regulation of air pressure can be cut out and the pressure regulated by hand, allowing manual control of all or part of the equipment.

Control of the Fuel Supply

The supply of fuel from the pulverizers is dependent upon the flow of air through the mill carrying the coal in suspension to the burners. The mill draft at the pulverizer inlet is kept constant by means of an adjustable damper in the air duct to the pulverizer regulated by means of a draft controller. With the draft at the mill thus kept constant, the output of the pulverizer is controlled by an automatic adjustable damper located in and part of the cast iron elbow in the exhauster inlet. The position of this damper with relation to the output is controlled by a lever connected to the air operated fuel control unit.

In order to roughly proportion coal input to output a second lever is located on the output damper shaft which, through a roller chain, actuates the feeder "Variacs." The "Variacs" of which there are three, one for each feeder, control the voltage to each of the vibrator feeders which regulate the feed to the pulverizers. Each of these Variacs is independently adjustable to allow a finer adjustment of the feed input.

To prevent the pulverizer from plugging, two level pipes are installed in the mill, identified as high and low level pipes. These pipes are connected to the bottom of the bell of the pulverizer feed controller. A connection is made at the top of the bell to a reference pipe also located within the pulverizer. When the coal level rises it will interrupt suction to the bottom of the pulverizer feed controller bell and atmospheric air will seep in through the small orifice tubes. This causes the

Principal Equipment in Rochester Gas & Electric Corp. Extension

BOILER AND FURNACE

Boiler—One Combustion Engineering Co., 4 drum, bent tube boiler, 250,000 lb. per hr. maximum capacity, fired with pulverized coal. Boiler 15,300 sq. ft., water walls 3990 sq. ft., superheater 4450 sq. ft., economizer 20,808 sq. ft.

Furnace volume 13720 sq. ft.

Boiler tube arrangement, 36 sect. of 20 each, tubes 3¼ in. O.D. No. 5 gage. Drums are steel plate, fusion welded joints, 42 in. and 48 in. dia., thickness of shell varying from 1 11/32 in. to 3⅝ in., all welds X-rayed.

Steam washer drum 48 in. dia. x 23 ft. 7 in. long, connected to the rear drum by 34-3½ in. tubes, cap. 250,000 lb. steam per hr.

Furnace walls, bare tubes, plain and fin type, backed by refractory, insulation and steel casing.

Operating Conditions — Max. continuous output—250,000 lb. steam per hr., 660 lb. per sq. in. gage, total temp. 755 deg. F.

Feed water entering boiler at 388 deg. F.

Firing Equipment—Two Foster-Wheeler Tricone ball mills No. 4, each connected through one No. 40 Exhauster fan, 15,200 lb. per hr. capacity each, with bituminous coal. Coal feeders are Jeffrey vibrating type. Each mill driven by 150 hp., 870 r.p.m. Westinghouse motor through a Bethlehem snub coupling.

Mill Exhausters are of the paddle wheel type, cast iron casing, rotor is cast steel spider with mild steel blades, and is mounted directly on the shaft of a 75 hp., 1200 r.p.m., 60 cycle, 3 phase Westinghouse motor.

Forced Draft Fan furnishes primary air to the pulverizers and secondary air to the burners. Fan is Clarage Fan Company No. 4, full housed, double width, double inlet, inlets equipped with adjustable Vortex control, and is direct connected to a squirrel cage 75 hp., 860 r.p.m., 3 phase 60 cycle, 440 v. motor through a flexible No. 4 Fast coupling.

Max. cap. 69,000 c.f.m., 4 ft. 5 in. S.P.

Steam Air Heater by American Blower Corp. consists of 6 units of Aerofin heaters with tubes 3 ft. 0 in. long, containing 1921 sq. ft. of heating surface. Four units have 3 rows of tubes each, and 2 units of 2 rows of tubes each.

Calculated performance with mill pulverizing 15,200 lb. coal per hr. is 30,000 lb. air per hr., 80 deg. F. entering air, 347 deg. F. leaving air. Condensate 2390 lb. per hr.

Burners—Four Combustion Engineering type R forced draft burners arranged 2 high and 2 wide, 14 in. dia. requiring 4 in. static press. of the primary air at burner inlet when supplied with 7600 lb. coal per hr., and 3800 c.f.m. of air from the mill.

Superheater—The Superheater Company, 4450 sq. ft. made up as follows: 35 two-loop, semi-radiant elements, 1¾ in. O.D. tubes, 1330 sq. ft., 53 four-loop convection elements, 3120 sq. ft. 1⅝ in. O.D. tubes.

A 2½ in. dia. Consolidated type safety valve set at 745 lb. is provided at the outlet header.

Economizer — Foster Wheeler extended surface, counter flow, 20,808 sq. ft. of external H.S. 24 rows high, 17 wide, elements 17 ft. 0 in. long, 2 in. Tubes No. 11 gage, with cast iron gills. Diamond soot blowers, 4 horizontal rows, 16 soot blower elements.

Ash Handling Equipment — Allen-Sherman-Hoff Co. Hydrojet ash system on furnace bottom, Hydrovac fly ash system on Economizer and Electrical Precipitator, all ash being sluiced under pressure through a concrete trench lined with nickel cast iron liners to collection point.

Soot Precipitator — Cottrell Precipitator by Research Corporation, consists of two units of 11 ducts, collecting electrodes of the rod type with a Solenoid operated rapping mechanism, and installed ahead of the induced draft fan.

Induced Draft Fan—Clarage Fan Co. No. 16 full housed, double width, double inlet, bottom discharge, taking gases from Precipitator and discharging to existing stack.

Turbine drive, 200 hp. Allis-Chalmers, 3645 r.p.m. with a single reduction herringbone gear unit, coupled through a No. 4 Fast coupling to fan running at 685 r.p.m.

Turbine operates with steam at 210 lb., 525 deg.: F. and exhausts at 5 lb. gage into deaerating heater, regulation by Bailey Combustion control.

Boiler Feed Pumps—Two Allis-Chalmers pumps, each in two units, each pump consisting of a primary pump 5 in. by 4 in., 3 stage and a secondary pump 5 in. by 4 in., 5-stage on a common base including driving turbine.

Capacity primary 618 g.p.m. secondary 730 g.p.m. total dynamic head of secondary 1485 ft.

Primary pump takes feed water from deaerating heater at 212 to 220 deg. F. and pumps through economizer to high pressure contact heater, secondary pump receives water at about 390 deg. F. and discharges into boiler.

Pumps driven by one Allis-Chalmers, and one Moore steam turbine, non-condensing.

Allis-Chalmers turbine 496 b.h.&p. at 3000 r.p.m.

Moore turbine 450 b.h.p. at 3450 r.p.m., 210 lb. steam pressure 525 deg. F., 5 lb. back pressure.

Regulation by Bailey controlled regulating valves in the steam supply lines.

Water Purification Equipment—Cochrane 32,000 g.p.h. deaerating type, hot process water softener consisting of sedimentation tank with feeding equipment for chemicals, phosphate and sodium sulphate, filters and water wash pumps, with auxiliary equipment.

Sedimentation tank built of copper bearing steel, welded construction, feeding tanks built of Toncon iron, welded construction.

Desuperheater — Blaw-Knox ductiweld construction, 36 in. dia. of body by 13 ft. 0 in. high. Steam going to the present low pressure turbo generators must be reduced to 525 deg. F. whether coming from the high pressure turbine exhaust or bypass steam from the boiler.

Feed water supply and blow down to reduce concentration are regulated by Bailey Thermo-hydraulic generators with metal bellows-operated regulated valves.

Continuous Blow-Off Equipment — Cochrane Corporation, consisting of one 2 in. forged steel needle control valve, one high pressure flash tank 24 in. dia. by 36 in. built for 250 lb. working pressure, one low pressure flash tank 48 in. dia. by 72 in. built for 50 lb. working pressure, one heat exchanger, 4 pass U tube type with 625 sq. ft. of heating surface, made up of 150—¾ in. copper tubes 21 ft. 6 in. long, built for 50 lb. working pressure.

Coal Handling — Robins Conveying Belt Co., capacity 125 t. per hr., consisting of apron feeder, Pennsylvania steel built, hammer-mill crusher belt and bucket elevator, belt conveyor and tripper, with electrical inlocking equipment for starting and shut down in the proper sequence.

Coal is delivered to steel plate, hopper bottomed bins, reinforced Gunite lined.

Coal crusher driven by 40 hp., 1200 r.p.m. Westinghouse a.c. motor.

Belt and Bucket Elevator, driven by 15 hp., 1200 r.p.m. Westinghouse motor through a Falk Herringbone speed reducer.

Link Belt duplex bumper gates.

BOILER AND SETTING

Combustion Engineering Corp. Sub-Contractor, Wm. Summerhays Sons Corp., Rochester.

Front Wall—18 in. firebrick to top of burners, above this point DeWolf Type "A", 9 in. refractory with 1 in. sticktite on back. Entire wall insulated with 3 in. rock wool blanket and steel casing.

Side Walls—DeWolf type refractory 9 in. and 7½ in. thick insulated with rock wool and steel casing.

Rear Wall—Above soot to upper rear drum 2 in. firebrick tile with 3 in. rock wool and steel casing.

Boiler and Furnace Roof carried on circulating tubes are 2 layers of 2½ in. firebrick insulated with rock wool and steel casing.

Side Water Wall backed by 2½ in. shaped firebrick to fit behind the fin tubes with 1 in. sticktite, air space, 3 in. rock wool and steel casing.

Rear Water Wall backed by 2½ in. of "Moldit" behind the fin tubes held in place by steel plate resting against the down-take tubes, 3 in. rock wall and steel casing.

Harbison-Walker refractories used.

BOILER ACCESSORIES

Water Columns—Two Diamond Power Specialty Corp. for 752 lb. drum pressure.

Water Level—One Diamond water level indicator connected to one of the water columns.

One 21½ in. vision length Diamond flat glass water gage with illuminator.

One 21½ in. vision length Diamond color water gage with reflector and floor mirror.

Blow-Down—3 Cochrane forged steel blow-off valves for 900 lb. press. One 2 in.—1500 lb. Edward forged steel needle valve.

Safety Valves—3 Consolidated Ashcroft Hancock 900 lb. pressure, set at 750 lb., 755 lb. and 760 lb. gage, respectively.

Soot Blowers—Diamond automatic valve-in-head 16—1½ in. units in Boiler—16—2 in. units in economizer.

Ducts and Breechings—Connery and Company.

Elevator—Graves Elevator Co., Rochester, combination freight and passenger.

Turbine Room Crane—Shaw-Box Crane and Hoist Co., 15 T. electrically operated.

Station Heating Units—Clarage Fan Co., Unitherm unit heaters.

Structures—A. W. Hopeman & Sons Co., General Contractor. Structural steel by Genesee Bridge Co.

River Water Strainer—1 B-10 rotary strainer, capacity 1050 g.p.m. for generator air cooler, transformers and house service water.

Temperature Recording Instruments and Gauges—Taylor Instrument Cos.

All piping fabrication and erection by W. K. Mitchell & Co., Inc.

High Press. Steam—Seamless steel pipe A.S.T.M. Specification A-106-34 T. Schedule 80.

Gaskets, steel ring, dead soft 1/32 in. thick.

Lunkenheimer valves, Edwards non-return valve.

Serrated faces on valves, and flanges where used, all other joints welded.

High Press. Exhaust — Seamless steel pipe, A.S.T.M. Spec. A-106-34 T. Schedule 20.

Gaskets, Klingerite 1/16 in. thick.

Valves, Reading, Pratt and Cady Co.

Boiler Feed Discharge—Pipe and gaskets same Spec. as High Press. steam, Lunkenheimer valves.

CONTROL EQUIPMENT

Bailey control system, entirely automatic (supplemented by hand). Primarily, the steam pressure, through a master pressure controller, determines the compressed air pressure regulating the fuel supply, and secondarily, the steam flow—air flow mechanism adjusts the compressed air pressure controlling the speed of the turbine driven induced draft fan for the coal given. The forced draft fan is regulated by the pressure in the furnace, which is maintained constant.

MAIN TURBO GENERATOR

General Electric Co. 6000 kw., .8 power factor, 3 phase, 60 cycle, 11.500 v., 3600 r.p.m., impulse type, non-condensing unit, with direct connected exciter.

Air for the generator ventilation is cooled by a 6 pass generator air cooler of 3350 sq. ft. surface, requiring 160 g.p.m. cooling water at 80 deg. F.

The exciter is directly coupled to the generator shaft with thrust bearings and separate bedplate, designed for 40 kw., 320 amperes, with 4 poles.

Steam at throttle 650 lb. gage, 750 deg. F. total temperature, exhausting at full load at 210 lb. gage, 530 deg. F. This gives the desired conditions for the present low pressure turbines.

Valve Control—Limitorque, Philadelphia Gear Works.

Station Power Transformers—1500 kva. 3 phase, 11,000/440 v. and 4150/440 v. inert gas. Allis Chalmers Mfg. Co.

Station Lighting Transformers—25 kv-a. single phase, General Electric Co.

Emergency Lighting—D.C. from Station Battery.

Generator Oil Circuit Breaker—600 amp. 15 kv. General Electric FHK-230-20B.

Generator and Transformer Cables—Paper and lead, 15 kv., General Electric Co. and Safety Cable Co.

Station Auxiliary and Lighting Conductors—2500 v. Kerite, Kerite Insulated Wire & Cable Co. 600 v. Kerite, Kerite Insulated Wire & Cable Co. 600 v. Rockbestos, Rockbestos Products Corp.

Motor Generator Set—5 kw. 125 D.C., Electric Products Co.

Variacs on fuel control system, General Radio Co.

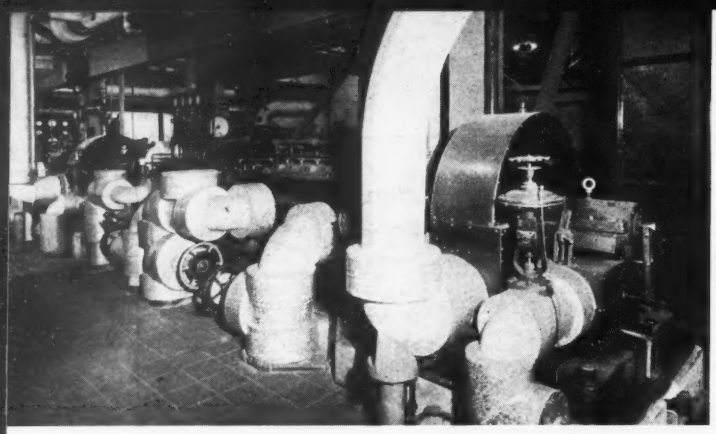


Fig. 12. Each boiler feed pump consists of a 3-stage primary and a 5-stage secondary pump connected together and mounted on one base and driven by a steam turbine. The two units are shown here

bell to rise and thereby trip the two mercoid switches interrupting the 110 v. current to the feeder units and cut in the current to a signal light on the boiler board.

As already mentioned, the forced draft fan is regulated to keep a predetermined draft pressure in the furnace. This is accomplished by Vortex control of the constant speed fan, the position of the vanes being regulated through a control unit by a compressed air piston motor.

The induced draft fan is turbine driven. A diaphragm operated steam flow valve in the steam line to the fan turbine regulated by the control system, regulates the speed of the fan to maintain the proper draft in the furnace.

The air supplied from the forced draft fan is passed partly directly as secondary air to the burners and partly as primary air to the pulverizer after being preheated in the steam air preheater. The amount of preheat is regulated by thermostatic control from the pulverizer exhaust duct which actuates the steam supply valves to the preheaters.

The foregoing presents the principle features of the combustion control system. In addition to the elements mentioned the system is also fully equipped with electrical interlocks to insure proper sequence in starting the equipment and to stop the equipment in proper sequence in case of failure of any part of the system.

Feed Level and Flow Control

The feedwater level control is shown at the left of the diagram in Fig. 11. This makes use of the Bailey three element control, which takes into account not only changes in water level in the boiler but also the ratio between main steam flow (the load) and the water flow to the boiler. The primary impulse in this system is obtained through the differential excess pressure control which operates directly upon the speed of the boiler feed pumps through the feedwater pump control valve. Either a drop in water level or an increase in steam flow (reduction in pressure in the boiler) will cause the speed of the feed pumps to increase. This increases the water flow to the boiler, raising the level which through the water level recorder and the water flow meter initiates an impulse tending to close the feedwater regulating valve, through the Standatrol relay which tends to delay the action. It will be noted that the Standatrol relay is also connected to the steam flow controller and as long as the normal ratio between the water flow and the steam flow is upset, the steam flow controller will prevent the Standatrol relay from closing the feedwater regulating valve.

The action is somewhat complicated but by means of this three element control not only the water level but also the correct ratio between steam flow from the boiler and water flow to the boiler is maintained at the proper value.

The control of the desuperheater temperature and level and the reducing valve between the high and low pressure systems is also shown in Fig. 11, at the right. This is simpler and is entirely independent from the feedwater control. The action of the desuperheater has already been explained briefly. The amount of superheated steam which flows through the upper part of the desuperheater, and consequently the amount which is desuperheated in the lower part, is controlled by means of a butterfly valve in the superheated steam line through a temperature control element acting through a Standatrol relay. The action of the reducing valve is similarly controlled except that in this case the actuating element is a pressure control element.

Conclusion

While we have been able to consider only the principal features of this new extension to Station No. 3 of the Rochester Gas and Electric Co., it will be apparent to anyone familiar with modern power plant practice that this station represents the best that present day engineering practice has to offer. Both the engineer and officials of the Rochester Gas and Electric Corp. and the E. M. Gilbert Engineering Cor-

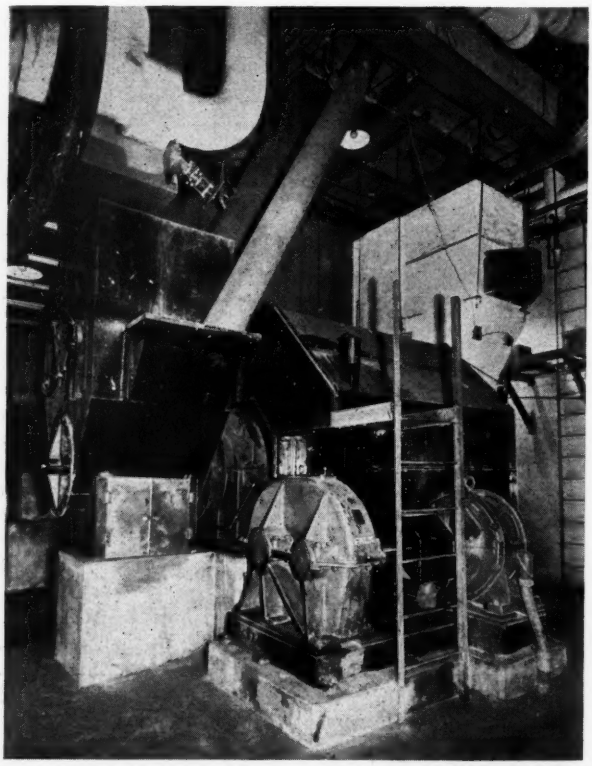


Fig. 13. One of the pulverizers, located in the basement below the operating floor

poration, who designed it, are to be complimented upon having produced so fine an example of modern power plant practice and to both of these organizations we express acknowledgment for courtesies and assistance rendered us in the course of preparing this article, and for the data, drawings and photographs involved in its construction. Acknowledgment is also made to the Bailey Meter Co. for photographs furnished.

Fig. 14. The Three Powells

The three Powells, concerned in the design and construction of the station. Left to right: Shepard T. Powell, consulting feedwater engineer and chemist; Ivan E. Powell, supt. of steam generation, Rochester Gas & Electric Corp.; supt. of steam generation, Rochester Gas and Electric Corp.; James A. Powell, E. M. Gilbert Engineering Corp. They are not related.

Particular attention is directed to the drawings and diagrams, these are unusually comprehensive and the reader will find much in them that necessarily was left unsaid in the article. The accompanying list of equipment also contains detailed data which could not be duplicated in the body of the article.

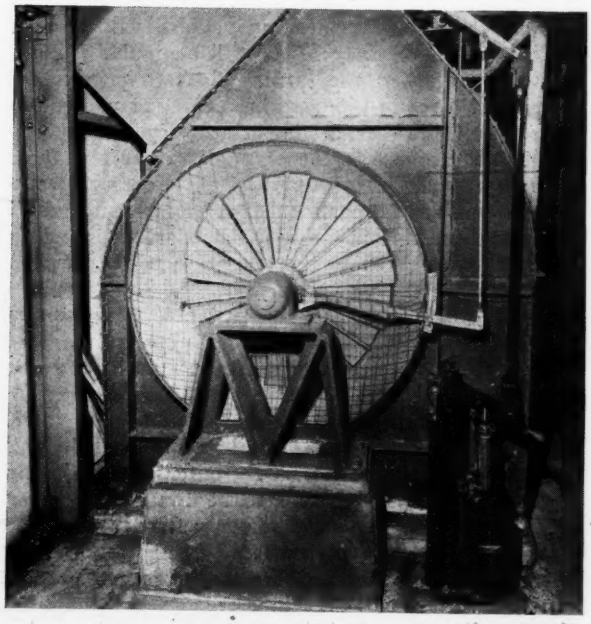


Fig. 15. The induced draft fan showing the Vortex control and the automatic actuating mechanism.

Hydrogen As an Auxiliary Fuel

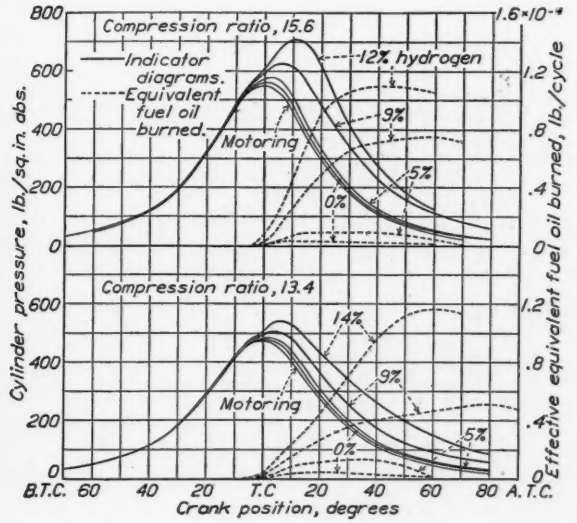
An Investigation was made at the Langley Memorial Aeronautical Laboratory (reported by Harold C. Gerrish and Hampton H. Foster in N. A. C. A. Report No. 535) where the performance of a single cylinder, four-stroke cycle compression ignition engine operating on fuel oil alone was compared with its performance when various quantities of hydrogen were induced with the inlet air.

Hydrogen could be burned satisfactorily in all loads up to and including cruising at a compression ratio of 13.4 and 15.6 in sufficient quantities to compensate for the increase in lift due to the consumption of the fuel oil. If hydrogen can be burned in the engines of an airship with the same efficiency as liquid fuel the fuel weight would be reduced 17.6 per cent and allow a proportionate increase in pay load.

Compensation for Weight of Burned Fuel a Serious Airship Problem

In the cruising range the mixture of fuel oil and hydrogen burned as efficiently as the fuel oil alone. At smaller power outputs the mixed fuel oil and hydrogen burn less efficiently than the fuel oil alone whereas for power outputs greater than that required for cruising the mixture of fuel oil and hydrogen burn more efficiently than the fuel oil alone. For all loads except idling there was present in the exhaust, water vapor weighing more than the fuel oil burned; when burning the maximum amount of usable hydrogen with the fuel oil, the weight of vapor was 80% more at full load and 200 per cent more at small load.

The engine always stopped firing when fuel oil was cut off. Throughout the limits of the test conditions, it was never possible to auto-ignite the various mixtures of oil and air but the injection of even a minute quantity of fuel oil would cause the mixtures to burn. The engine showed no ill effect through the use of hydrogen and no change in engine operation was apparent.



Effect of Hydrogen on Combustion when 0.507 Lb. per Cycle of Fuel Oil is Used for Ignition

Controlling 1,500,000 Lb. of Steam per Hour

The governor for this 160,000 kw. turbine must hold the frequency within a fraction of a cycle. Governor and lubricating systems separate.

By A. F. SCHWENDNER

Control Engineer, South Philadelphia Works, Westinghouse Electric & Mfg. Co.

STEAM FLOW to any prime mover must be controlled by some type of governing system in such a manner that changes of load will produce only relatively small changes in speed. Various governing systems have been successfully applied since the advent of the earliest turbine installations and it is only when the volume of steam to be regulated reaches relatively high values that new problems arise in the application of the hitherto fairly standardized control systems. Regulating valves become large in size and their position will depend upon the number and location of the admission points in the turbine cylinder. They must not require complicated turbine cylinder construction and they must be so designed as to be independent of the effects of temperature distortion.

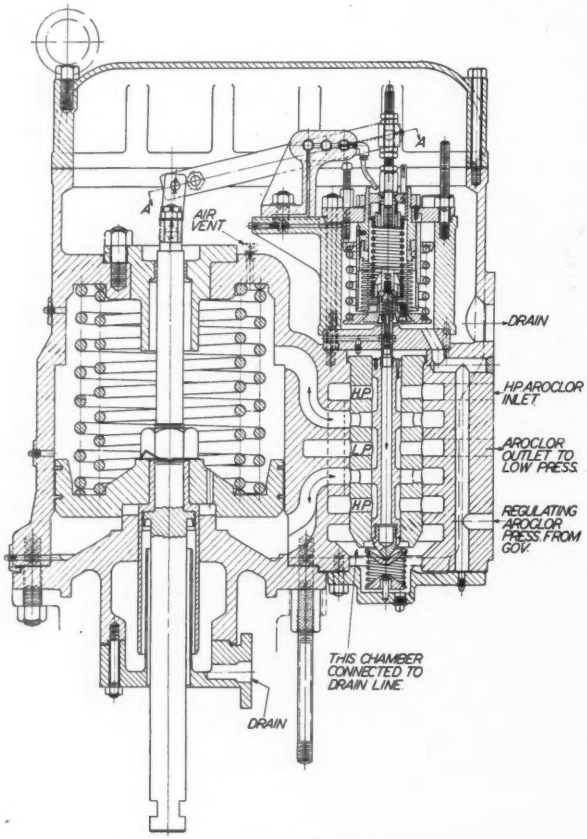


Fig. 1. Valve Operating Mechanism

In the case of one of the most recent large turbine installations approximately 1,500,000 lb. per hr. of steam is admitted to the turbine at four inlet points, requiring seven regulating valves. This installation is arranged with two throttle valves, one throttle valve together with one regulating valve, being located at either side of the turbine cylinder. These valves supply steam to the inlet of the first blade group and also to the steam chamber in the cylinder cover. Steam from this chamber is admitted to the second inlet zone through one, to the third inlet zone through two, and to the fourth inlet zone through two regulating valves. Obviously, the size and multiplicity of these valves necessitates a control mechanism of high sensitivity and rapid response, combined with ample operating power.

In the installation under discussion the actuating force for the control system is the change in pressure in a primary governor oil system, supplied at constant pressure through an orifice and povided with a relief or drain outlet by way of a drilled angular passage through the end of the turbine shaft. The effect of centrifugal force in this rotating relief passage causes a change of pressure in the primary system proportional to the square of the change in speed and these pressure changes are transmitted to a pressure transformer causing proportional but greatly magnified changes of pressure in the secondary system, by which they are transmitted to the operating mechanisms of the several regulating valves.

Regulating valves are of the double plug type, a combination of two single seated plug valves, one placed within the other. The inner valve opens first and passes steam to an inlet zone, thus decreasing the pressure drop across the seat of the outer valve. When the inner valve has been lifted through its full travel, it makes contact with the outer valve and any further upward movement of the inner valve then lifts the outer valve also. The steam flow through the regulating valves is proportional to the valve lifts. This regulating feature is obtained by proper proportioning of the inner and outer valve areas and lifts. The flow lift characteristics of the double plug valve can be made identical to those of a ported regulating

valve. The double plug type valve is used with a diffuser valve seat. The use of the diffuser has permitted the application of valves far below the conventional sizes, without any increase of the pressure drop. The high steam temperatures involved require a careful selection of materials used for valve parts. The inner valve is of nitrided steel, while the outer valve and valve seat are made of stainless steel. The stainless steel valve stem is used in connection with nitrided steel bushings.

Opening and closing of each steam regulating valve is controlled by a separate hydraulically operated mechanism. The movement of each mechanism is controlled by a regulating fluid pressure. The valve operating mechanism, shown in Fig. 1 is so constructed that the movement of the operating piston is proportional to the regulating fluid pressure. This means that the steam flow through the regulating valves is proportional to the regulating fluid pressure.

Regulating pressure enters the bellows chamber through drilled passages in the cylinder. The regulating pressure acts on the effective area of the bellows in an upward direction and together with the tension of the spring between the bellows and return link, just balances the downward force of the load spring in the bellows chamber. The main relay is moved downward by the liquid pressure above the relay, which is supplied through an orifice in the relay body. The compression spring below the main relay moves the relay in an upward direction. The movements of the main relay are controlled by the pilot relay attached to the bellows. An increase in the regulating pressure moves the bellows and the pilot relay in an upward direction. The liquid pressure above the main relay will drop due to the increased flow between the main and pilot relay. The spring below the main relay will move the relay upward until the increase in liquid pressure on top of the main relay balances out the spring force. The main relay in this position admits high pressure motive fluid under the operating piston and allows the fluid on top of the piston to discharge.

Resultant upward motion of the operating piston is checked only when the return link decreased the spring tension by the exact amount the regulating pressure forced the bellows upward. This will bring the bellows, pilot and main relays into neutral position. The amount of piston travel corresponding to a given regulating pressure change can be altered by changing the tension spring scale, the fulcrum point of the return link or both. The operating mechanism linkage and other moving parts are force lubricated and enclosed in vapor and dust tight casings. After the valve operating mechanisms are set to operate in their proper sequence, no other adjustment or attention is required. The operating mechanism regulating pressure lag is a maximum of 0.2 lb. This means that less than two-tenths of a pound regulating pressure change will move the operating piston, even at points of large valve load changes.

Steam flow to a turbine is usually regulated to be proportional to change in speed. The regulating mechanisms so far described regulate the steam flow in proportion to a regulating pressure change. The governor impeller briefly described before and shown in Fig. 2 will funish a regulating pressure proportional to the square of the revolutions per minute of the turbine shaft and so closing the link between the steam flow and speed. Figure 2 shows the complete regulating diagram. It also shows two centrifugal impellers located on the turbine shaft between the thrust bearing and the auto stop governor. The one on the left serves as the main oil pump and supplies all the oil requirements while the turbine is operating at full speed. The suction to the oil pump is supplied by ejectors which

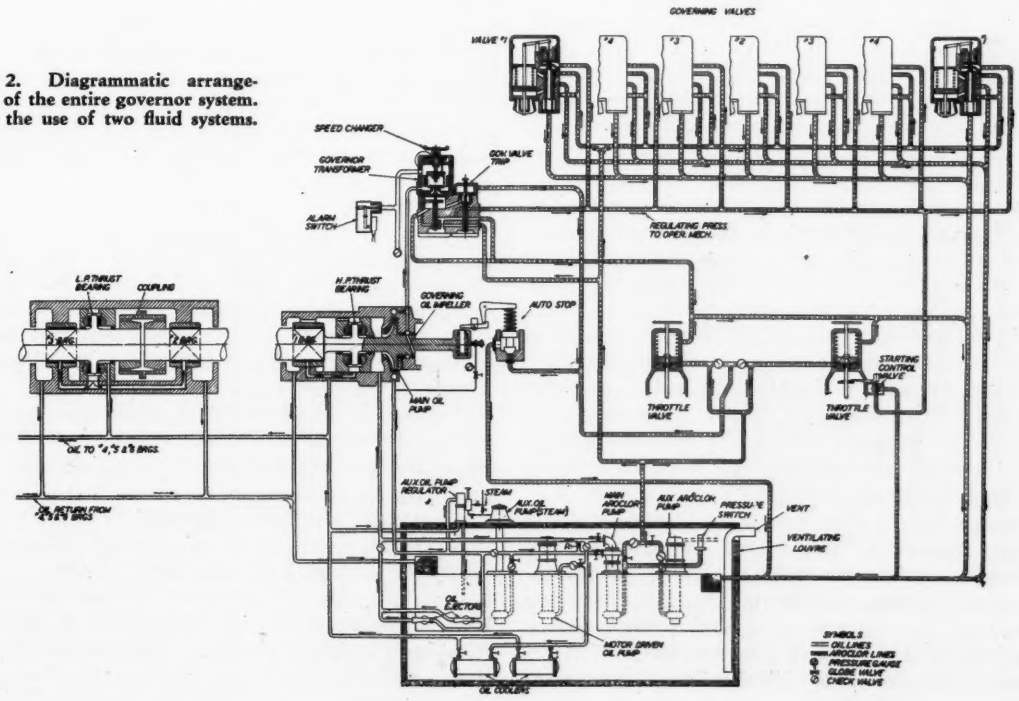


Fig. 2. Diagrammatic arrangement of the entire governor system. Note the use of two fluid systems.

use part of the high pressure oil while operating at normal speed. During the starting period the suction is supplied by the auxiliary pump.

The governor impeller, on the right, is merely an inclined hole drilled in the turbine shaft. A chamber is formed at one end of the hole and sealed with oil rings while the other end of the hole is open to the drain chamber. The discharge chamber of the main oil pump is connected through an orifice to the governor impeller chamber. A small amount of oil flows through the orifice into this chamber and maintains a pressure which varies as the square of the turbine speed. Any excess oil supplied through the orifice above that required to maintain the pressure in this chamber passes beyond the center of the shaft and then out to drain.

Governor oil impeller pressure is 40 lb. at 1800 r.p.m. A 4 per cent speed change will give an impeller pressure change of 3.2 lb. Using the impeller pressure as the regulating pressure for the valve operating mechanism a speed change of 4½ r.p.m. would be required to produce the two-tenths of a pound pressure change to reverse the operating piston travel. Obviously, the speed change to move the operating mechanism is too large for stable regulation. To reduce the required speed change the transformer mechanism mentioned above is placed between the governor impeller and the operating mechanism. The transformer increases the pressure changes of the governor impeller about sixteen times without a trace of pressure or time lag. The use of the transformer reduces the 4½ r.p.m. speed change to less than 0.3 r.p.m. The combination of impeller and transformer may be regarded as a single speed-sensitive device whereby ± 1 per cent of speed change is converted in to ± 12.8 lb. per sq. in. of pressure change.

The transformer mechanism, shown in Fig. 3 also serves to separate the oil which is used to lubricate the turbine bearings from the aroclor or other non-inflammable liquid which is used as motive and regulating fluid in the throttle and valve operating mechanisms. The pressure changes which are produced by the governing impeller are transmitted to the transformer by oil and exert an upward force on the effective differential area of the regulating bellows. The bellows seal the oil chamber from the aroclor operated transformer relay. The transformer relay is kept revolving at all times, by a jet of aroclor directed against a turbine element mounted on the relay, so as to reduce the friction to a minimum and make the mechanism highly sensitive. The control annulus of the relay may communicate with high pressure aroclor below and with the drain connection above. This control annulus of the relay is connected to the chamber below the relay, also through external piping to each valve operating mechanism. With the relay in its neutral position, the force of the governing oil below the bellows, plus the force of the aroclor below the relay must balance the downward force of the speed changer spring.

Assuming that the mechanism is in operation the following outlines a complete cycle of its control. If due to increase in load the turbine speed decreases, the governing oil pressure below the bellows decreases, thus allowing the compression spring to move the relay downward. This places into communication the high pressure aroclor inlet with the central annulus of the relay which increases the regulating pressure until its force at the bottom of the relay again balances the compression spring and so returns the relay to its neutral position. This increase in regulating pressure also acts on the valve operating mechanisms so as to open the steam valves. It should be noted that the change in regulating pressure is dependent on the ratio of the effective areas between bellows and relay. Assuming the effective area of the bellows to be 16 sq. in. and the area of the relay 1 sq. in., an increase of 1 lb. oil pressure below the bellows will produce a 16 pound decrease in the regulating pressure to balance the spring load. With 4 per cent speed variation the governor impeller discharge pressure changes 3.2 lb. while the transformed regulating pressure changes approxi-

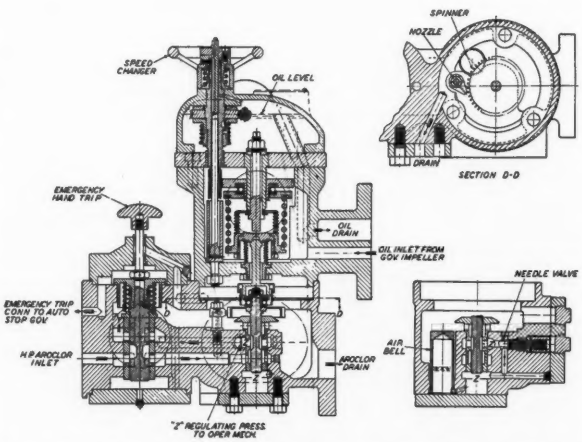


Fig. 3. Transformer which amplifies the pressure changes from the governor impeller into powerful operating pressures to move the steam valves

mately 51 lb. This regulating pressure change is more than ample to insure close operating mechanism follow-up even with a number of regulating valves.

The control system just described is able to follow the smallest speed changes with a proportional change in steam flow, without appreciable lag. The location or number of regulating valves does not effect regulation, while the regulating valve construction reduces the manufacturing and heat distortion problems of the turbine cylinders.

MORE THAN one million dollars in cash has been saved by fuel users of Hudson County, New Jersey, as a direct result of smoke abatement activities, according to the annual report of William G. Christy, Smoke Abatement Engineer for the County. "For 1935, the fuel saving was $247,000. The accumulated savings for the first 4 yr. of smoke abatement totaled $754,000. This gives a total of $1,001,000, representing the dividends paid on smoke abatement since the Department of Smoke Regulation was established 5 yr. ago. Violations on industrial plants have decreased 93 per cent in 5 yr. Steamships, tugs and ferries show a 94 per cent improvement in violations of the smoke ordinance. Hudson County smoke inspectors made 41,809 observations on all classes of plants and recorded 494 violations, or slightly more than 1 per cent of observations."

FUEL OIL HEATERS*

By JAMES O. G. GIBBONS

Data pertinent to the selection of the proper size and installation of fuel oil heaters in power plants.

IN ORDER to reduce the viscosity of the heavier oils, such as No. 6 and sometimes No. 5, it is necessary to raise their temperature to from 125 deg. F. to 250 deg. F., depending upon the viscosity of the oil and the type of burner used. For this purpose it is necessary to provide heaters, which are generally operated with steam, but in some cases hot water or electricity can be used.

Efficiency of radiators and heaters is a topic of considerable discussion. Unfortunately the term efficiency, when applied to heaters, does not as a rule, refer to the relationship of B.t.u. output to B.t.u. input.

The term heater efficiency more often describes in a somewhat indefinite way, the amount of heat which will be transmitted per square foot of heating surface, and except as it may affect the purchase price of the heater, or the space occupied, it is of very little practical importance.

In the correct sense, it may be said that all heaters are practically one hundred per cent efficient, because except for incidental radiation losses, there is nowhere for the heat to go, except into the fluid to be heated, and if it does not go there the heater will automatically fail to take the steam and condense it. This is an important fact to keep in mind, as heater efficiency is a popular selling argument.

It is difficult to estimate just how much heat transfer surface will be required to heat a given amount of oil to the desired temperature, as it depends to a great extent upon the rate of flow of the oil over the heating surfaces, as well as other conditions.

If we look for information in an engineers' hand book, we shall probably find that the B.t.u. transfer per hour between a condensing vapor and a liquid, per degree difference, per square foot, may be anything between 150 and 1000, which is certainly not very definite.

In practice it will probably be found that 5 sq. ft. per gallon per minute will be ample for most types of fuel oil heaters, and will take care of temperatures up to about 250 deg. F., but only actual tests under operating conditions can furnish reliable information as to the performance of any particular type of heater.

Five square feet per gallon per minute, assumes a low unit heat transfer, but there is a tendency to form deposits on the heating surfaces when operating with oil, and in connection with this, it may be stated that when the heater has the steam in the coils and the oil in the outside case, the heat transfer surfaces will probably keep cleaner than when the oil flows through a coil or a number of small pipes.

In figuring the heat required for a given temperature rise of oil it will be near enough to assume that the specific heat of oil is 0.50.

Relief Valves Are Essential

Some of the local ordinances require that oil heaters shall be equipped with pressure relief valves. This is a good precaution for if the oil inlet and outlet valves are closed and the steam left on, a dangerous pressure may be built up by the expansion of the oil.

Thermometers should be installed at the outlet of each heater to indicate the temperature of the oil, and these should be shown on the installation drawings, as the fire insurance bureaus will generally ask for this, as well as a thermometer at the pump suction to indicate the temperature of the oil as it comes from the tank.

It is usual practice to install at least two heaters, each one of which should be of sufficient capacity to take care of the total load when operated with live steam. It is often possible to take care of most of the temperature rise in one heater with exhaust steam, and the other heater may be used as a booster, operating with live steam under thermostatic control. With steam atomizing burners, exhaust steam will generally take care of the total temperature rise, and automatic temperature control can be provided to furnish live steam should the exhaust fail at any time to give the required temperature.

Electric Heater for Special Service

For starting up, when there is no steam on the boilers, it is advisable to furnish an electric heater, which may consist of a 5 kw. immersion element screwed into a length of pipe with tee fittings for the inlet and outlet of the oil. These heaters can be operated with a three-heat switch which gives a satisfactory range of control. Of course a more elaborate automatic temperature control can be furnished if desired, but as the use of the heater is generally only temporary, it is seldom necessary to provide anything but a simple hand control.

With those types of installations which do not require the oil to be heated to a high temperature, hot

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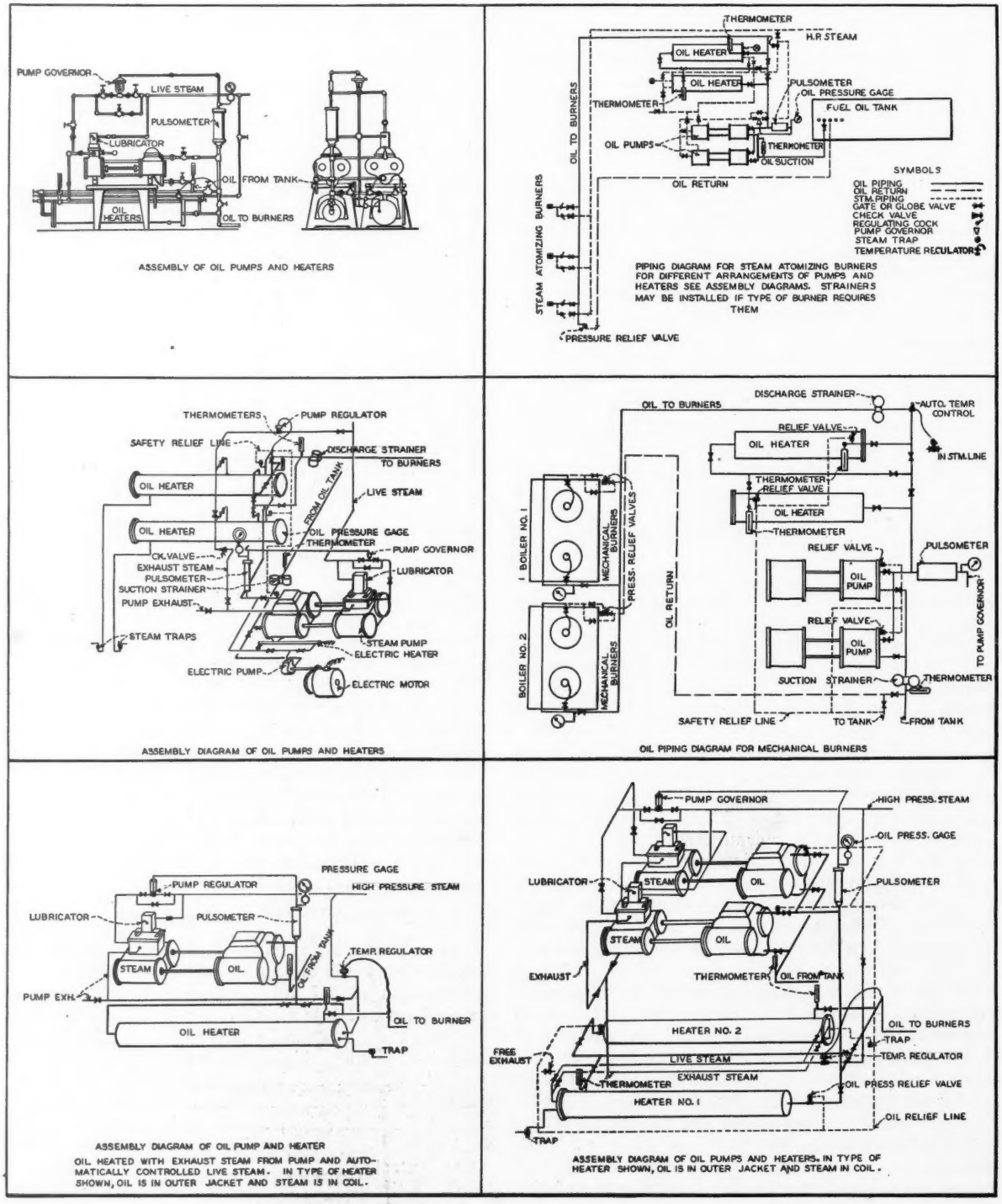
water can be used in the heaters, but generally this is not very satisfactory, and steam should be used wherever possible.

It is, as a rule, better to install the heaters in a horizontal position than in a vertical position, as there is less tendency to form a gas pocket which should be avoided as far as possible. Gas pockets must always be avoided, particularly after the oil has been heated. Pipes looped overhead from the heaters and then down to the burners are likely to give trouble through the accumulation of gas, which may cause the burners to puff and operate in an unsatisfactory manner. To a certain extent, the same principle applies to suction lines, as slugs of gas may seriously interfere with the operation of the pumps, and the oil in the tanks should not be heated to over 100 deg. F.

Different methods of installing heaters are illustrated here.



Piping diagrams for fuel oil heaters and pumps

Oil Engine Electric Generating Station Operating Costs

Operating economies that may be expected of oil engine electric generating plants up to 30,000 br. hp., presented to the A.S.M.E.

By GEORGE C. EATON

Head Mechanical Technical Engineering Division, Generating Department, The Edison Electric Illuminating Co., Boston, Mass.

RAPID DEVELOPMENT in recent years of the oil engine, particularly in the larger sizes, coupled with the relatively low cost of suitable fuel oil, has resulted in the application of these engines as prime movers for central-station service in many localities. Some months ago, the author had occasion to prepare operating costs for a proposed oil-engine-electric generating station, the exact size or annual output of which was to be determined later. It, therefore, became necessary to prepare data that could be quickly applied to a plant of any given size and annual output. With this in mind, the author developed a series of curves from the best available data, the reports of the Subcommittee on Oil Engine Power Costs of the A.S.M.E. covering some 323 station years.

Data on plants of less than 1000 total installed brake horsepower were not considered inasmuch as the proposed plant was to have considerably greater capacity, and the inclusion of data on such relatively small plants might introduce unnecessary errors.

No data on the capacities in kilowatts of the various plants were given in the reports; hence it was necessary to compute these, using an assumption similar to that of the Subcommittee on Oil Engine Power Costs, as follows:

Capacity in kw. = Installed br. hp. $\times$ 0.746 $\times$ 0.9.

The common abscissa chosen for the curves was the annual capacity factor that in itself includes the two fundamentals (capacity and output), unknown in the problem. The capacity factor is defined as follows:

$$\text{Annual capacity factor} = \frac{\text{Annual net output in kw. hr.}}{\text{Capacity in kw.} \times 8760 \text{ hr.}}$$

Points in Fig. 1, which has as ordinate the total fuel in gallons used per year per kilowatt of capacity, were determined from the data as follows:

$$\text{Fuel used in gallons per year per kw. of capacity} = \frac{\text{Annual net output in kw. hr.}}{\text{Capacity in kw.} \times \text{fuel rate in kw. hr. per gal.}}$$

A second degree curve was fitted to these plotted points in Fig. 1 by the method of moments. From this curve, Fig. 2 was developed using fuel costs from one to ten cents per gallon.

Figure 3 was developed directly from Fig. 2 by dividing the ordinate of any point by its abscissa and the proper constant (8.760) to give the unit cost in mils per kilowatt hour at any capacity factor for fuel costs from one to ten cents per gallon.

Points for Fig. 4, which has as ordinate the total operating cost, except fuel, in dollars per year per kilowatt of capacity, were determined from the data as follows:

$$\text{Operating cost in dollars per yr. per kw.} = \frac{\left(\begin{matrix}\text{Annual net output} \\ \text{in kw. hr.}\end{matrix}\right) \times \left(\begin{matrix}\text{Cost (except fuel)} \\ \text{in mils per kw. hr.}\end{matrix}\right)}{\text{Capacity in kw.} \times 1000}$$

where for each station-year (in mils per kw. hr.): Cost (except fuel) = Total production cost less fuel cost.

A second degree curve was fitted to these plotted points in Fig. 4. From this curve and the curves in Fig. 2, Fig. 5 was developed by the addition of the ordinates of the respective curves.

Figure 6 was developed directly from Fig. 5 by dividing the ordinate of any point by its abscissa and the proper constant (8.760) to give the unit costs per kilowatt hour at any capacity factor for fuel costs from one to ten cents per gallon.

It is the author's hope that these curves may be of value to other engineers in the course of their work in prognosticating the operating costs of plants yet unbuilt. It is recognized that there is opportunity for considerable divergence from the values given, as the plotted original data clearly shows. However, in estimating studies, an engineer can only look to the past for experience and view the future according to his best judgment.

The author believes that these curves based on plants ranging from 1000 to 15,640 br. hp. may be safely extrapolated to 30,000 but beyond this point, the better operating economy due to inherently larger units should certainly be considered. Further, it should be recognized that the author has made no attempt to correct the original data for type of engine, method of fuel injection, method of scavenging, heat content of the fuel, altitude, locality with respect to labor costs, etc.

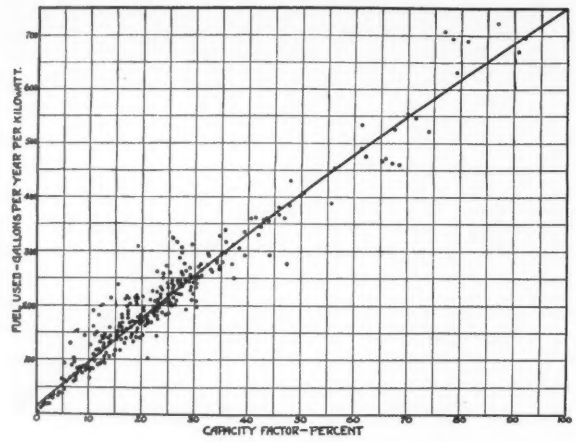


Fig. 1. Annual fuel consumption as a function of capacity factor. Curve fitted to data as reported in the A.S.M.E. Diesel Engine Cost reports

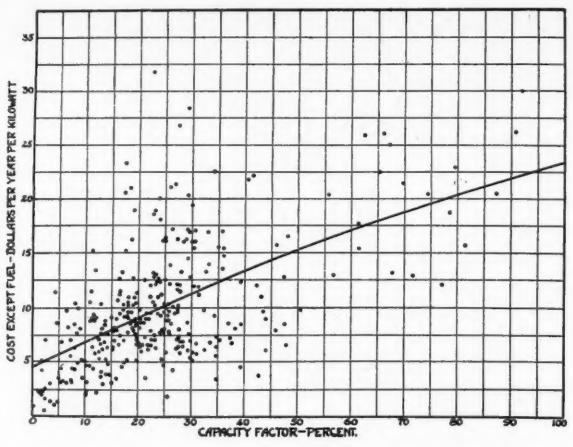


Fig. 4. Annual operating costs, exclusive of fuel, do not show such close agreement as the fuel costs Fig. 1. This data also from the A.S.M.E. reports

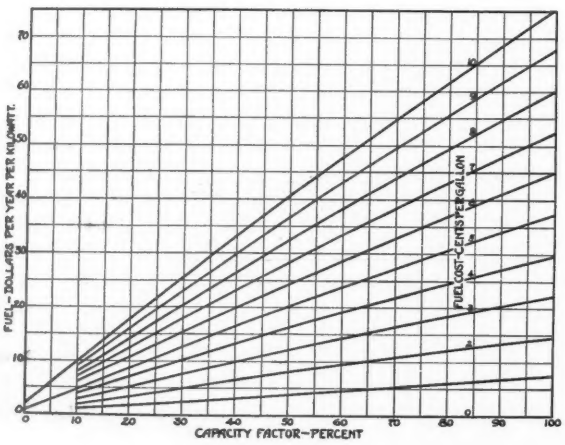


Fig. 2. Annual fuel costs based upon the capacity factor and the cost of fuel in cents per gallon for the range of 0 to 10 cents

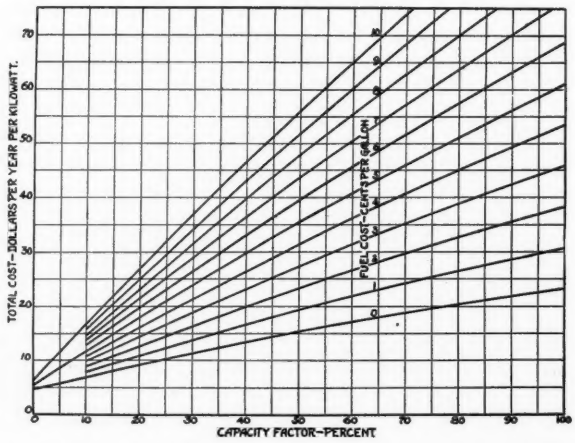


Fig. 5. Total annual operating cost curves for different price fuels obtained by combining the curves of Figs. 2 and 4

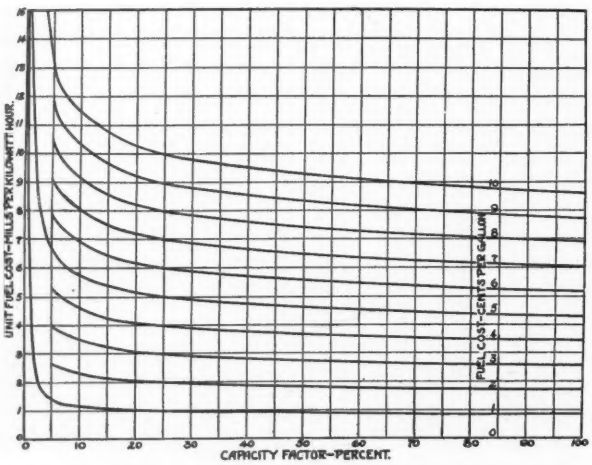


Fig. 3. Unit fuel cost curves calculated from Fig. 2 as indicated in the text

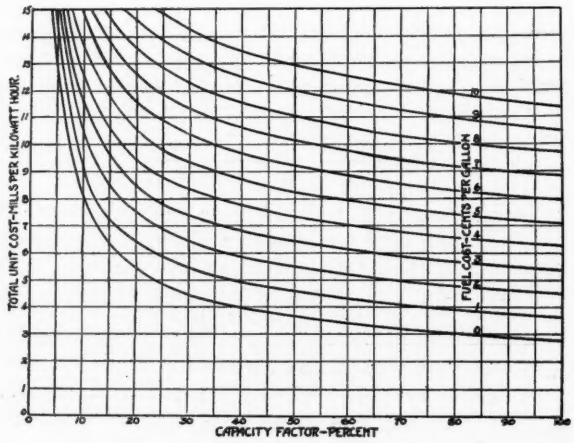


Fig. 6. Total unit operating costs calculated from Fig. 5 for different fuel costs

The Explosion Hazard *of* Compressed Air Machinery

BY J. M. MYERS

USE of compressed air machinery has increased until even in the small and remote plants that purchase their electricity, one or more pieces will usually be found. So little has been written along this line that even the most experienced operators are likely to overlook the hazard connected with this equipment.

Safety is often aided by the use of compressed air equipment, but it also introduces a new danger that can only be eliminated by proper care in installing, maintaining, and operating the equipment.

The use of compressed air equipment has increased considerably in the last few years, and men have been killed and injured by the explosions of air compressors and receivers, and also by the injection of compressed air into the eyes, ears or nose.

Special care must be exercised in operating air compressors. They must be strongly built, installed on a firm foundation, and securely fastened in place. Variable loads on air compressors cause considerable vibration, and impose a severe shock on it, and a severe strain on the flywheel. Proper care of the speed governors are very important, as excessive speed develops too much heat, which increases the danger of explosion in the compressor, and too high a peripheral speed often causes failure of the flywheel. The belts, pulleys and flywheels should all be properly guarded.

Air receivers and air piping when not used properly are also a hazard. The tanks should be made of boiler plate as specified in the A.S.M.E. Boiler Code. Tanks made of lighter metal such as household hot-water tanks, are often used but are dangerous and their use has resulted in many explosions. The maximum allowable working pressure of an air receiver depends on the size, tensile strength of metal used, efficiency of joints, and factor of safety. Safety valves properly set, and regularly tested, should be installed on each container. A drain trap, with bypass and test valve should be installed at the lowest point on each container, and in some cases on the lowest parts of the pipe lines. These traps should be frequently checked to see that all oil and water are kept drained off. A pressure gage should be installed on the air receiver, and if a cutoff valve is used between the compressor and receiver, a spring pop valve must be installed on the air line between the compressor and the valve.

The exact causes of explosions in air compressors, receivers and pipes are not thoroughly understood, but the best authorities recommend that special attention be given to compressor lubrication, cleanliness of air intake, air cylinder temperature, and cooling the air between stages after compression.

Some authorities attribute air compressor explosions to the volatilization of the lubricating oil and the ignition of the resulting oil vapor. Whether or not this is true, it is a fact that the temperature of the air is increased considerably in the process of compression. At a pressure of 100 lb., the temperature in the cylinder often reaches 400 deg. F. This temperature is sufficient to volatilize certain grades of lubricating oils which have a low flash point. This oil vapor when added to compressed air will form an explosive mixture which may be ignited by the temperature of the compressed air or by a glowing bit of carbon. Therefore, it is necessary to use high flash point oils in the air cylinders. (The flash point of any substance is the minimum temperature at which it gives off a flammable vapor.)

Operators should be careful not to supply too much oil to air compressors, as excessive oil increases the danger of explosions. The walls of air cylinders are dry and do not require as much oil as steam cylinders where steam and moisture washes the oil from the wearing surfaces. The oil required for small compressors is from 1 to 4 drops per minute; medium sizes, 6 drops per minute and from 10 to 12 drops for very large compressors.

Danger of explosion is also increased because of the decomposition of the lubricating oil. Use only a high grade mineral oil. Vegetable oil must not be used. Even the best grade of oil decomposes to some extent when exposed to intense heat, and leaves a carbon deposit on the cylinder walls which may be carried over into the pipe or container. This carbon deposit is flammable and soon becomes oil soaked. If it is under pressure and exposed to great heat it readily glows and may even burn, thus igniting any flammable or explosive mixture of oil vapor. The burning of this carbon may heat certain spots on the cylinder walls, pipe or receiver to such a high temperature that it can not withstand the pressure of the air and bursts with explosive violence. If oil burns in the air line and does not cause an explosion, it often forms carbon monoxide gas which mixes with the compressed air in such a proportion as to cause death if breathed.

To prevent the formation of excessive carbon deposits it is advisable to feed the oil slowly into the air cylinder, to use only high grade mineral oil, and to clean out the cylinders, valves, discharge pipes and air receivers at frequent intervals. This may be done by feeding a soap solution into the air cylinder for two or three hours at a time. One pound of soft soap to seven quarts of water is mixed for the solution and it is fed about ten times as fast as the oil is ordinarily supplied. A lye solution is then fed into the discharge pipe and air receiver to clean them. One pound of lye is dissolved in nine quarts of water and fed through a lubricator at the rate of 65 drops per minute.

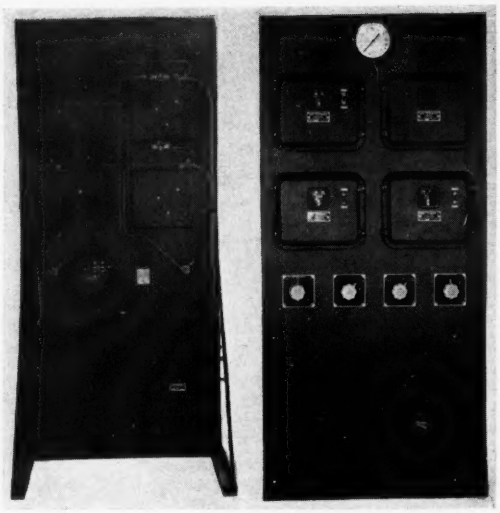
After cleaning, the compressors, air lines and receivers should be drained and operated with normal oil feed for a few minutes to prevent rusting.

If carbon cannot be removed this way it must be hand scraped. Kerosene or other inflammable substances should not be used to soften the carbon.

The air intake pipe should be located at a place where cool, pure air can be had, and a suitable filter provided to remove dust particles. Care must be taken to prevent the intake of inflammable gas fumes. The temperature of the air cylinder must be kept as cool as possible. This is usually accomplished by means of a water jacket, through which cold water is passed.

Combustion Control

Part XIV. Metermax, the Combination Pneumatic and Electric System of Leeds & Northrup Co.



FUNDAMENTALLY, control systems may be divided into three parts: a primary element that detects the indication of change and passes it on to a secondary element, or elements that interpret the indication for transmission to tertiary elements that do the actual work of moving the dampers and controls. The system is analagous to a manufacturing plant where the superintendent (primary) receives an order, transcribes it into shop language and sends carbon copies to various departments where each foreman (secondary) selects his portion of the work and gives definite instructions to the workmen (tertiary) to proceed.

In boiler controls changes in steam pressure are taken as indications of change in load. Variations are detected by Bourdon elements (or diaphragms or bellows) and, in the systems so far described, indications are transmitted to secondary elements, called pilot valves, by direct linkage or air pressure. The pilot valves in turn control air or oil flow to the operating cylinders or tertiary elements in such a way as to maintain the desired fuel-air ratio.

In the Metermax system of Leeds & Northrup Co., the pilot valves, used in the previous systems, have been replaced with electrical contacts and the hydraulic or pneumatic operating cylinders by electric motors. The system is a simplification of the all-electric control made by the company for many years and thus combines elements of both the pneumatic and electric systems.

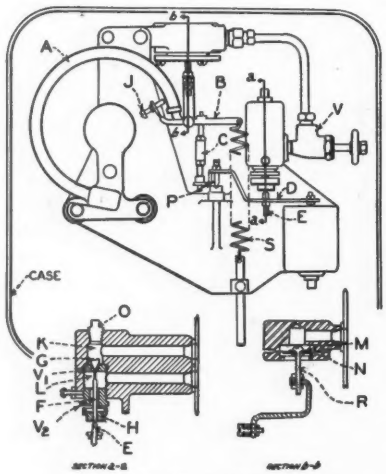


Fig. 1. The Master Controller

This controller consists essentially of a Bourdon tube, an air regulating valve assembly, a balance arm with connecting linkage and a steam pressure compensator. The Bourdon tube A is subjected to header steam pressure and the resultant force due to this pressure is transmitted to lever arm D by means of bell crank B and connecting link C. The opposite end of balance arm D carries pivot E, supporting valve stem F which in turn carries throttle valve G and bleed valve H acting in conjunction with valve seats V_1 and V_2 respectively.

Control air supply pressure is led into supply pressure chamber K and the combined action of throttle valve G and bleed valve H regulates the master air loading pressure in chamber L. The balance arm D is free to rotate on pivots P and the controller therefore balances the force due to steam pressure on the Bourdon tube against the force due to loading spring S and the force due to the air pressure on throttle valve G and bleed valve H.

Since tension of spring S and the air supply pressure acting on throttle valve G are practically constant, the net effect of the controller action is to vary air pressure in chamber L as steam pressure changes on the Bourdon tube.

The range of steam pressure on the Bourdon tube required to vary the master air loading pressure in chamber L over its working range may be varied by changing the size of the bleed cup valve H or changing the radius at which connecting link C is attached to the balance arm D. Three sizes of cup valves are provided with the controller and holes for attaching the connecting link at two different points on the balance arm are available.

Changes in header steam pressure acting on the Bourdon tube vary inversely as a function of boiler steam output and the master controller functions to vary the master air loading pressure in chamber L inversely as the header steam pressure applied to the Bourdon tube. The resultant of this controller action is a master air loading pressure which varies as the square of boiler steam output.

Adjustment of the value at which it is desired to hold header steam pressure is obtained by means of pressure adjustment screw J and loading spring S.

Normal action of the master controller is such that a drooping steam pressure characteristic is obtained. In other words, header steam pressure decreases as load on the boilers increases. This condition is desirable in many installations since it prevents wide variations in boiler drum pressure with variations in boiler steam output.

In other cases, however, it is desired to maintain header steam pressure substantially constant over the working range of boiler output and in these cases the master controller is provided with a steam pressure compensator, shown by Section **a-a.** This compensator consists of a loading air pressure chamber M, a flexible diaphragm N rigidly connected to the Bourdon tube by means of rod R, a throttle valve V and a capacity tank (not shown in Fig. 1 but visible at the upper left hand corner of the rear panel view shown in the headpiece).

Master air loading pressure is led to the chamber M and applied to the upper surface of diaphragm N, so that the change in force due to changes in the master air loading pressure assists the force due to changes in steam pressure on the Bourdon tube A. In service, the action of this compensator is as follows:

An increase in steam demand causes a slight drop in header steam pressure which in turn causes the Bourdon tube tip to move downward so that throttle valve G is opened slightly and bleed valve H is closed. This action increases the master air loading pressure in proportion to the drop in header steam pressure. This increase in master air loading pressure is slowly communicated to the compensator diaphragm N which further increases the downward force on the tip of the Bourdon tube and produces the same effect as a further decrease in header steam pressure.

An additional rise in master air loading pressure then occurs, which increases combustion rate sufficiently to return the header steam pressure to its normal value. By means of throttle valve V and the capacity tank mounted at the rear of the controller, this compensator action can be retarded so that it takes place at the proper rate to return header pressure to its normal value gradually without overshooting.

A typical schematic Metermax layout for pulverized fuel is shown by Fig. 2. Air from the plant system, or from a separate compressor, passes through a reducing valve which maintains a constant pressure of 8 in. of water on the low pressure side. This pressure passes the throttle valve G (built as part of the master regulator described in detail in Fig. 1). The master regulator is responsive to steam pressure. A drop in header pressure, indicating an increase in load causes the end of the Bourdon tube A to bend inward and more nearly close leak off valve H. The loading pressure on the system inside of throttle valve G will therefore depend upon the position of leak off valve H. When H is closed tight the loading pressure will approach the maximum of 8 in. When H is wide open the loading pressure will approach the minimum or atmospheric pressure. Maximum loading pressure therefore occurs at maximum steam load as indicated by minimum header pressure.

This loading pressure acts simultaneously on the air flow controller, described by Fig. 4, and the fuel feed controller, described by Fig. 3, so as to maintain the fuel-air ratio set by the fuel-air rheostat. The fuel feed and tachometer output are directly proportional to the feeder speed while the pull developed by the solenoid coils (in the controller to balance the loading pressure) varies as the square of the tachometer current or output. Likewise in the air controller, the differential pressure across the last pass used to balance the loading pressure varies as the square of the gas flow. Therefore, both the fuel feed and air flow vary as the square root of the loading pressure, or directly proportional to each other, the exact ratio depending upon the setting of the fuel-air rheostat.

Furnace pressure is maintained at a constant value by the furnace pressure controller, shown at the right of Fig. 4. The drive shown on Fig. 2 actuates both the fan and damper. When under the action of the controller, the damper moves to its wide open position, contacts shown at the motor close and increase the fan speed sufficiently to back the damper away from the contact. When the damper closes too far the opposite contact is made and the fan speed reduced until the damper moves back to its normal range. When minimum fan speed is reached, the damper is free to move to its full closed position.

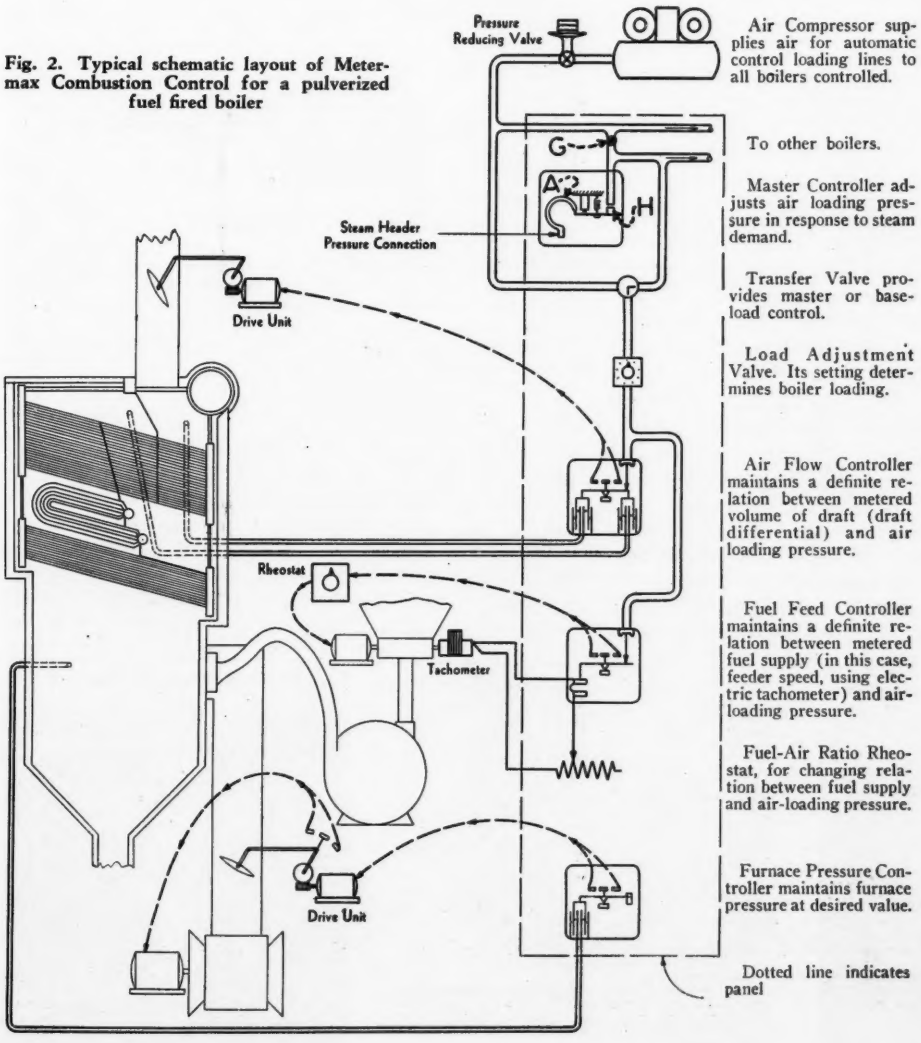

Pressure Reducing Valve
Air Compressor supplies air for automatic control loading lines to all boilers controlled.
To other boilers.
G
A
H
Master Controller adjusts air loading pressure in response to steam demand.
Steam Header Pressure Connection
Drive Unit
Transfer Valve provides master or base-load control.
Load Adjustment Valve. Its setting determines boiler loading.
Air Flow Controller maintains a definite relation between metered volume of draft (draft differential) and air loading pressure.
Rheostat
Tachometer
Fuel Feed Controller maintains a definite relation between metered fuel supply (in this case, feeder speed, using electric tachometer) and air-loading pressure.
Fuel-Air Ratio Rheostat, for changing relation between fuel supply and air-loading pressure.
Drive Unit
Furnace Pressure Controller maintains furnace pressure at desired value.
Dotted line indicates panel

Fig. 2. Typical schematic layout of Metermax Combustion Control for a pulverized fuel fired boiler

As shown in the headpiece, all units are mounted on a panel which is assembled in the shop and shipped as a unit. The photograph shows a master panel with the air loading pressure indicator at the top, the master controller and air flow controller on the right, the fuel feed controller and furnace pressure controller at the left and four control switches (from left to right) fuel-air rheostat, selector switch, transfer valve and load adjustment valve at the bottom. Individual boiler panels are the same except for the omission of the master controller.

These four switches provide flexibility in the system. The fuel-air ratio control is a rheostat in the tachometer circuit which provides a true ratio change, so that a correction made at one load is maintained over the full control range. Usually this rheostat is manually controlled but automatic CO_2 compensation can be

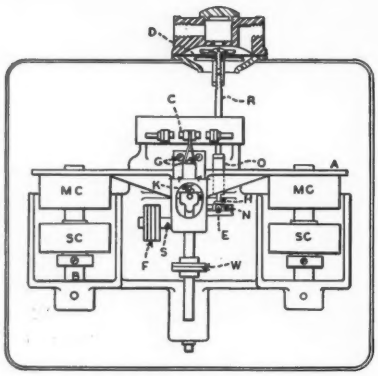


Fig. 3. The Fuel Controller

This controller consists of a loading pressure diaphragm, a pair of stationary electrical coils and a balance arm carrying a pair of movable electrical coils and a set of electrical contacts. The movable coils MC are rigidly fastened to the balance arm A which is supported on pivots K. Each stationary coil SC is mounted on the core B and is adjustable vertically on this core.

The four controller coils are connected in series in such a way that the electric current passing through them (representative of the rate of fuel feed) exerts a force on balance arm A tending to deflect it to the left. The electric coil current is ordinarily set up by an electric tachometer linked to the fuel feeder or stoker. An air loading pressure is applied to the upper surface of diaphragm D and the resultant force due to this loading pressure is transmitted to the balance arm A by means of rod R and pivot H. This loading force tends to deflect the balance arm to the right and, therefore, opposes the force due to the electric current on the controller coils.

When the pivoted balance arm is in equilibrium, a force proportional to air loading pressure is balanced by a force representing the rate of fuel feed. When the two forces are not in balance the balance arm deflects either to the right or to the left, as the case may be, causing a moving contact C to touch an "increase" or a "decrease" stationary contact.

A corresponding motor drive unit is thus actuated so as to change the rate of fuel feed until the balance is restored. As soon as the balance is restored the contacts separate and the motor drive unit remains stationary until the next change occurs.

Two sets of contacts are provided at the controller, one set being directly behind the other as shown by Fig. 4B. When the degree of unbalance is small the front moving contact at C touches an "increase" or "decrease" stationary contact to make corrective movements of the drive unit which are of short duration. When the degree of unbalance is greater the tilt of the balance arm is increased until the rear moving contact at C touches the corresponding "increase" or "decrease" stationary contact to make greater corrective steps by running the drive unit motor for longer periods.

The degree of unbalance required before making these larger corrective movements of the drive unit is adjustable over a wide range, by varying the gap between the rear moving contact C and the corresponding stationary contacts. This adjustment is accomplished by loosening the locknut on the stationary contact and then screwing the contact in or out of its supporting bracket, as desired.

Duration of the short and long contact impulses to the drive unit motor are determined by adjustments of interrupter contacts which intermittently energize the two moving controller contacts for periods of different lengths.

Adjustment of the fuel-air ratio maintained by the control is made by means of a rheostat connected in series with the coils of the fuel feed controller. The controller coil current or force can be changed with this rheostat, for a given speed of the feeder or stoker tachometer.

added if desired. The selector switch is of the standard rotary drum type with two positions, "automatic" and "pushbutton." In the "automatic" position, the switch connects the electric current supply to the contacts of the various individual controllers at the corresponding boiler. In the "pushbutton" position of the selector switch, the contacts of the various controllers are disconnected and push buttons, which may then be used to obtain centralized remote manual control of each motor drive unit, connected.

Flexibility of Control

Electric push buttons of the standard momentary contact type, for manual control are located on the front covers of the various individual controllers, at the right of the window as shown by the panel photograph. The corresponding circuits remain closed only as long as the button is held down. While the selector switch is in the "pushbutton" position, the transfer valve may be turned without affecting the controls and may thus be used, with the single air loading pressure gage, to balance the "master automatic" and "individual automatic" systems before change over.

The transfer valve is a standard 3-way cock, as shown schematically in Fig. 2. It serves to connect the air loading system of a particular boiler either to the master controller, or directly to the constant discharge pressure at the outlet of the pressure reducing valve. The two positions of this valve are designated "master automatic" and "individual automatic." The latter setting is employed for base load operation of a boiler, with the combustion rate dependent only upon the setting of the load adjustment valve. In order to obtain either of the two types of automatic control above, the selector switch must be set at "automatic."

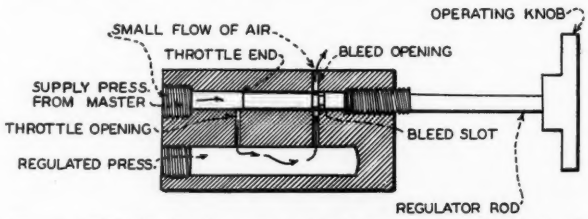
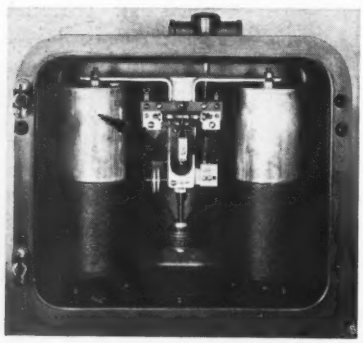


Fig. 5. This load adjustment valve determines the boiler load. It is located in the loading line as shown by Fig. 2 and acts as a manually controlled auxiliary bleed valve in the air loading line.

The load adjustment valve, shown by Fig. 5, is of the combination throttle and bleed type, and can be employed to reduce the pressure of the loading air supply to it, to any desired lower value. The full diameter section of the rod partly covers the throttle port at one end, and the bleed port at the other. By rotating the knob, the threaded rod moves endwise, so as to fully cover the throttle opening at one extreme of travel, or to fully cover the bleed opening at the

(Continued on p. 236)

Fig. 4A. The air flow controller

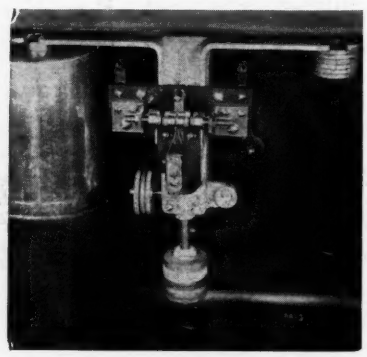


The construction and operation of the air flow controller is substantially the same as that of the fuel feed controller shown by Fig. 3 with the oil-sealed bells substituted for the solenoid coils. Loading pressure is applied to the balance arm from a diaphragm, in the chamber visible above the case, through a rod (R of Fig. 3). The pressure differential balanced by the loading pressure is proportional to the square of the gas flow through the boiler and thus the air flow is directly proportional to the fuel flow as set by the fuel flow controller.

The furnace draft controller is substantially the same as the other two controllers but as the furnace pressure is maintained constant at one pressure connection, and is not acted upon by the loading pressure, the loading diaphragm is eliminated and one bell replaced by a counterweight.

All controllers are provided with double contacts as shown at the right to provide short or long contacts depending upon the magnitude of the departure from normal conditions.

Fig. 4B. The furnace pressure controller



Liquid Oxygen Production

FOR USE as an explosive, to replace dynamite, use of liquid oxygen has been developed, a combustible cartridge being soaked in the liquid oxygen at the time that it is required, then detonated by a fuse or a special electrical detonator. The advantage is safety, in that the explosive is prepared only a few moments before use and, if not fired, the oxygen evaporates after an hour so that the cartridge is no longer explosive. Saving in cost is also claimed, if the mine or quarry is located within easy reach of a liquid-oxygen plant.

This has led to the building of a plant by an association of iron mines in the Briey Basin, near Meurthe-et-Moselle, France, which is described in Engineering of London, Eng.

Liquid oxygen is produced by liquefying air, then distilling off the nitrogen as a gas, leaving the oxygen as a liquid. Low temperature required to liquefy air is obtained by expanding highly compressed air either through expansion valve or, preferably, doing work in the cylinder of a prime mover, since the working expansion gives about double the cooling effect of free expansion, and the work done can be utilized in compression of air. The gaseous nitrogen comes off at —319 deg. F. at atmospheric pressure and is used to cool such of the air, about 70 per cent, as is passed through working expansion cylinders to —22 deg. F., leaving it still capable of doing considerable work during expansion from 3000 lb. pressure to 60 lb.; the balance of the air is cooled to a lower temperature and expanded freely. The expansion of this air cooled at 3000 lb. pressure results in its liquefaction. Work furnished by the working expansion is some 8 per cent of that needed for compression of the free air to 3000 lb. pressure, and air temperature doing the working expansion is lowered from —22 deg. to —265 deg. F.

Main compressors are of 5-stage type, horizontal, belt-driven from electric motors. The auxiliary, air-driven compressor, is single-acting, single-cylinder, taking air from the discharge of the second stage of the main compressors at 135 lb. and discharging at 450 lb.

Diagram of the plant action is as shown, main compressors and receiver being omitted. Compressed air at 3000 lb. is taken through pipes *k* or *l* to one of the twin heat exchangers *i*, *j*, used alternately so that any ice formed from water vapor in the air may be defrosted without interrupting operation. To defrost, part of the warmed nitrogen from the other exchanger is passed through the jacket and discharged at *o* or *p*, water from melted ice being drained from *q* or *r*. Cooled air from the bottom of the heat exchanger is led, part to the auxiliary compressor and part to cooler *c*, where it is further cooled and then expands through a valve into chamber *s*, expansion converting it into liquid form at 60 lb.

Liquid nitrogen, gathering in the top of *s*, is led to the top of column *t* through a cooler *u*, to prevent evaporation when the nitrogen passes from 60 lb. in *s* to 19.5 lb in *t*, nitrogen from *t* being used as the cooling agent in *u*.

Expanded air from the auxiliary compressor goes to the bottom of *s* and, passing up through the sprinkler plates, has the less volatile portion, largely oxygen, taken out by falling liquid from the cooler *c*. Thus practically pure nitrogen collects in the top of *s* and liquid which is 40 per cent oxygen collects in the bottom. This bottom liquid is passed through a riser and valve *g* to the middle of tube *t*.

Vapor, mostly nitrogen, passes up through the pipes at *e*, the outsides of which are washed by liquid oxygen in the bottom of tube *t* and is condensed.

By regulating valves *f* and *g*, which are kept nearly closed, pressures in columns *s* and *t* can be adjusted until pure liquid oxygen is formed in the bottom of *t* and pure nitrogen vapor in the top.

Liquid oxygen is withdrawn through the valve at the right of *e* into spherical storage tanks, having two compartments, the upper of 105.5 gal. capacity into which the liquid is led and the lower of 2006.5 gal. capacity, the two being separable by a valve, so that liquid can be removed from the lower part into transport tanks while it is collecting in the upper part. The transport tanks are spherical, carried on trucks and have capacities of 528 and 792 gal. Tanks of 1.3 to 2.6 gal. capacity are charged from these for use in the shafts and pits.

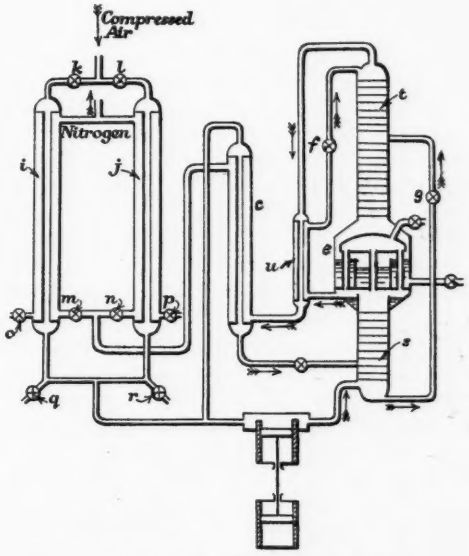


Diagram of liquid oxygen plant

With air at 29.9 in. of mercury and at 60 deg. F., the time from a cold start to reach normal production is 110 min. and after 24 hr. shut down is 40 min. Oxygen formed is 99.5 per cent pure. Energy used per pound of oxygen liquefied is 0.387 kw-hr. as metered to the motors and 0.341 kw-hr. at the compressor shaft. Loss per hour from the storage tanks, which are surrounded by an insulating coil shell carrying a coil of pipe through which oxygen gas evaporating from the tank passes, is 0.09 per cent an hour.

Electron Tubes — Principles *and* Applications

Part III. The fundamental principle of the two electrode tube. Its use as a rectifier

By A. W. KRAMER

ELECTRON TUBES ARE MADE in a great variety of types, and sizes, and for a variety of purposes but the fundamental principles involved in all of them are the same. All have a cathode which serves as a source of electrons and one or more additional electrodes for controlling or receiving these electrons. The electrons are drawn across the space between the cathode and other electrodes and this passage of electrons represents the current through the tube. The electron emission from the cathode may be produced in various ways. In the "thermionic" tube it is brought about by heat; by raising the temperature as already explained. In the photoelectric tube, it is accomplished by the action of light, indeed, the concept of the photoelectric tube originated when Hertz noticed that one of his spark gaps would break down more easily when illuminated on its negative electrode. In certain other types of tubes other methods are employed in producing the electron current, but these are of a special nature and need not be discussed now; for the present only the thermionic type of tube will be considered.

The simplest thermionic tube consists simply of a hot cathode and an anode, usually called the "plate," sealed in an evacuated bulb. Such a tube is called a "diode," the family name for two element tubes. Tubes containing more than two essential elements are called by different names but we can forget about those here and confine our attention only to the two element tube or diode.

As will be explained more fully below, such a tube, containing only a hot cathode and a plate is, fundamentally, a rectifier—a non-return valve in an electric circuit. Current can pass through the tube in one direction but not in the reverse direction. When the tube is connected into a circuit containing a battery or other source of potential, and if the connections are made so that the plate is positive with respect to the cathode, electrons boiled out of the cathode by the heat, are attracted and absorbed by the plate. When the polarity is reversed, however, and the plate made negative with respect to the cathode, nothing happens, since the plate is cold and therefore does not emit electrons.

Now, this is all that there is to the matter, and this really is all we are going to tell you in this article. If you stopped reading at this point, insofar as the fundamental principle of the two electrode tube is concerned you would understand it, perhaps as well as if you read the rest of this article. If, however, you feel that you would like to know a little more about the actual relations between cathode temperature and the voltage across the tube or how the tube is connected into a circuit it is suggested that you read on. There are a number of interesting things about the action of the tube which should be understood. Consider the cathode, for example; how is it heated and what form does it take?

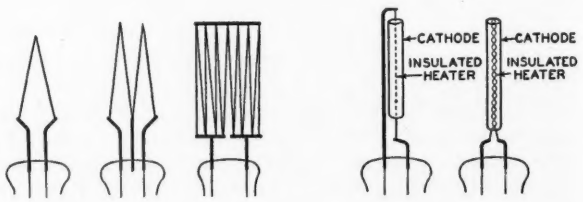
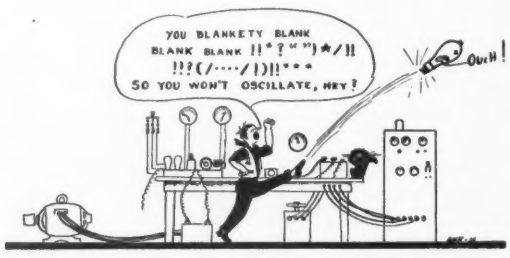


Fig. 1. Types of Cathodes

The cathode may be heated directly or indirectly. For example, a directly heated cathode usually is simply a wire heated by the passage of an electric current, similar to the filament of an ordinary incandescent lamp. The filament of an incandescent lamp actually does emit electrons in this way. An indirectly heated cathode consists of a filament or heater enclosed in a metal sleeve. The sleeve carries the electron emitting material on its outside surface and is heated by radiation and conduction from the heater. Insofar as the actual mechanism of emission is concerned, the principle in both directly and indirectly heated cathodes is the same.



TUBES ARE SOMETIMES CALLED BY DIFFERENT NAMES

The cathode is an essential part of any electron tube since it supplies the electrons necessary for the tube's operation. When the cathode is heated, electrons are liberated from the surface and are projected into the space beyond, forming a sort of invisible cloud around the cathode. The air is removed from the tube to permit the free movement of the electrons and to prevent the disintegration of the cathode surface by the active molecules of oxygen.

If there are no other influences acting in the tube the electron cloud surrounding the cathode remains unchanged so long as the cathode is maintained at a

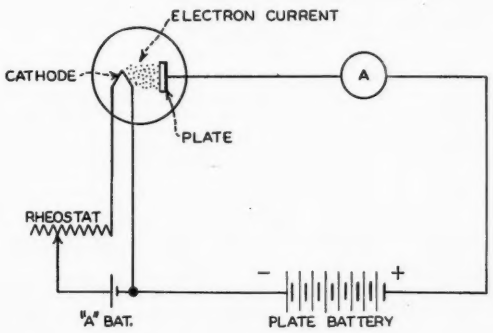


Fig. 2. When the plate is given a positive potential by connecting it to a battery, electrons emitted by the hot cathode are drawn across the intervening space between cathode and plate

definite temperature. Electrons are continually being emitted but as many fall back into the cathode as are emitted so a balanced condition ensues. The reason for this will be clear upon a moment's reflection. Before the temperature of the cathode is raised, it may be considered electrically neutral, that is it possesses no electric charge of any kind. When electrons are liberated, however, the cathode as a whole is left with a deficiency of electrons and since electrons represent negative charges, the cathode exhibits a slight *positive* charge and tends to draw back into its surface the electrons which have been emitted. Thus, at any instant, as many electrons are drawn back into the cathode by this positive charge as are emitted due to the thermal effect. The higher the temperature of the cathode, the greater will be the speeds and the kinetic energy of the electrons leaving the surface and the greater will be the extent of their travel before they fall back, but in any case a condition of equilibrium will be attained and the only effect of the higher temperature will be a greater radius of "electron cloud." Such a condition actually exists in an ordinary tungsten lamp, for in such a lamp the filament is heated to a sufficiently high temperature to produce copious electron emission.

Suppose, however, that a positively charged metal plate is introduced into the tube, as is the case in the diode. As shown in Fig. 2, this positive charge is imparted to the plate by connecting it to the positive terminal of a battery or direct current generator, the negative terminal of which is connected to the cathode. The electrons are negatively charged, hence they are attracted by the positively charged plate. Under the influence of the positive potential, the electrons surrounding the cathode are drawn to the plate and return through the external battery circuit to the cathode, thus completing the circuit. This flow of electrons is called the "plate" current and it may be measured by suitable ammeters just as any other electric current. It was this plate current that Edison detected in his early lamp experiments though he did not realize its implications.

The strength, or value, of this plate current, as may be suspected, is dependent upon two factors: first the temperature of the cathode, and second the value of the positive potential applied to the plate. When the cathode is cold, the tube forms an absolute barrier to the flow of electricity through the circuit, even though the full potential of the plate battery is impressed across it.

Assume, however, that the cathode is gradually heated (by cutting out resistance in the filament circuit). As the temperature rises, a point will be reached where electrons will begin to be emitted from the metal in accordance with the principles described. As they

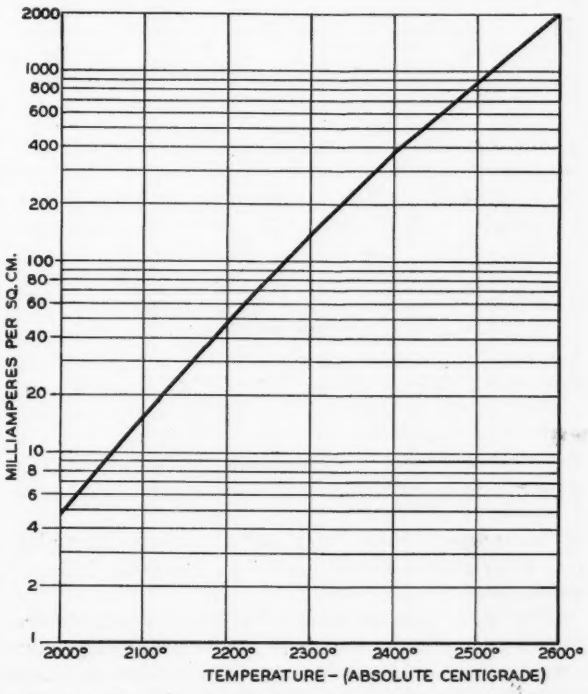


Fig. 3. Curve showing filament current plotted against plate current

emerge they will be drawn to the plate under the action of the positive plate potential and the plate current will be established. At first this current is very small because only comparatively few electrons are liberated.

As the cathode temperature is increased, more electrons are emitted and, as a consequence, the plate current increases. If the plate current is plotted against cathode temperature a curve such as that shown in Fig. 3 will be obtained. This shows clearly that the plate current is definitely related to the cathode temperature.

The number of electrons reaching the plate, however, is also dependent upon the value of the positive plate potential. The higher the positive potential, the more intense will be the attractive force acting on the electrons and the more rapidly will they be drawn to the plate. Thus, with the filament temperature held

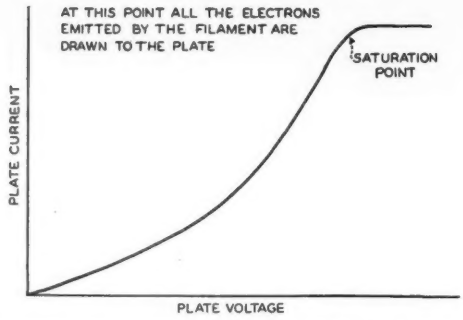

AT THIS POINT ALL THE ELECTRONS EMITTED BY THE FILAMENT ARE DRAWN TO THE PLATE
SATURATION POINT
PLATE CURRENT
PLATE VOLTAGE

Fig. 4. Variation of plate current with variation of plate voltage

at constant value, as the plate potential is slowly increased from zero, the number of electrons drawn to the plate also increases.

If the increase of plate potential is continued, however, a value will be reached at which all of the electrons emitted by the cathode are attracted to the plate. When this value is reached any further increase in plate potential will cause no further increase in plate current. This is known as the saturation current.

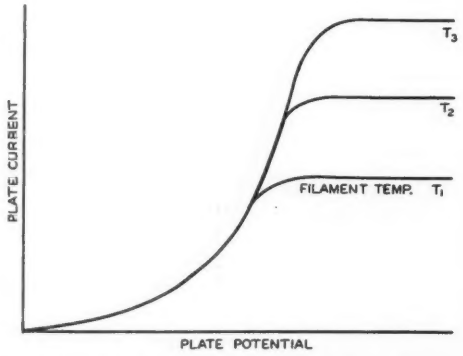


Fig. 5. Saturation currents for various cathode temperatures

If the value of the plate current is plotted against plate potential, a curve of the general shape shown in Fig. 4 will be obtained.

The saturation current so obtained is that corresponding to a definite cathode temperature only, however. A further increase of cathode temperature brings about a further increase in the number of electons emitted and as a consequence a new saturation current is established. So, for each cathode temperature there exists a corresponding value of saturation current. In each case, this saturation current represents the value of plate potential where all of the electrons emitted by the cathode are drawn over to the plate.[1]

Having these relationships between cathode temperature, plate potential and plate current clearly in mind, let us now consider briefly a simple though fundamental application of the two electrode tube in an electric circuit.

So far, we have considered only the action of the tube when a positive potential is applied to the plate. Suppose, now, instead of a positive potential, we apply a negative potential to the plate by connecting it to the negative terminal of the battery as shown in Fig. 6. It is quite evident that under these conditions no current can flow, for now any electrons that might be

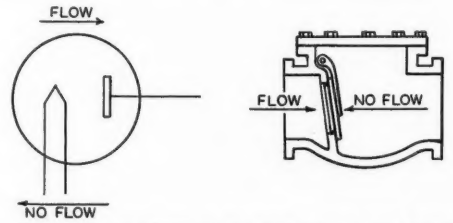


Fig. 7. The diode by virtue of its "unilateral" conducting property is similar to a non-return valve in a piping system

emitted by the cathode are immediately forced back into the cathode by virtue of the powerful negative field exerted by the plate. And since the plate is cold, it cannot emit electrons. Thus, the tube permits electrons to flow from the cathode to the plate when the plate is positive but not from the plate to the cathode when the plate potential is reversed. The tube, therefore, acts very much as a non-return valve in a piping system, permitting current to flow in one direction but not in the reverse direction.

This unilateral conducting property of the diode

[1]Since the saturation current is a measure of the number of electrons emitted by the cathode for a certain temperature, the value of this current can be calculated by means of the general equations given by Richardson for the number of electrons emitted by hot bodies. Richardson's original equation is as follows:

$$N = AT^c e^{-b/T}$$

in which N is the number of electrons emitted per second. A, b and c are constants depending upon the nature of the cathode substance and T the absolute temperature. e is the base of the natural system of logarithms.

In the case of an ordinary tungsten filament, the constant c in the above equation is ½. Then, the saturation plate current I for a given filament temperature T in a tube having a perfect vacuum, is given by the equation:

$$I = A\sqrt{T}e^{-b/T}$$

where A, b and e have the same meaning as above.

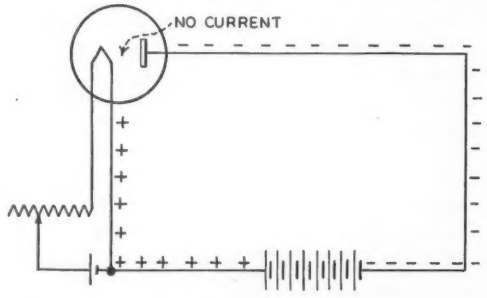


Fig. 6. When the plate is charged negatively no current flows through the tube

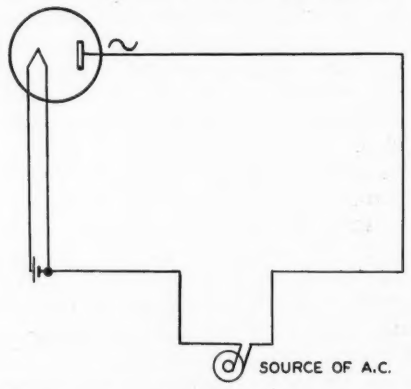


Fig. 8. When an alternating potential is applied to the plate, current will flow only during the successive half cycles when the plate is positive

enables it to serve as a rectifier of alternating current. If an alternating potential is applied to the plate, as shown in Fig. 9, the plate will be made alternately positive and negative. Since the tube conducts current only when the plate is positive, the negative half of the cycle is suppressed and there will flow in the plate circuit a pulsating direct current of the type shown at B in Fig. 9. A single tube of this kind, therefore, constitutes a half wave rectifier and as such it has been

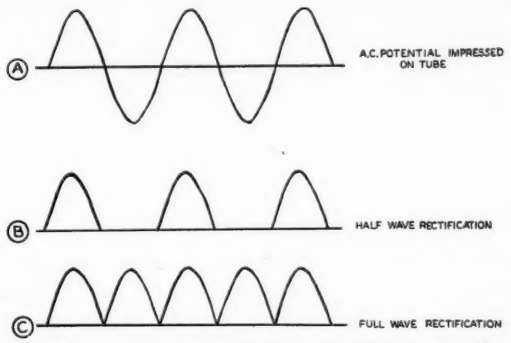


Fig. 9. Wave diagrams showing half the full wave rectification

extensively applied in the charging of storage batteries. The "Tungar" and "Rectigon" battery chargers in universal use today employ rectifying tubes of this general type.

This rectifying principle of the two element thermionic tube or diode was first recognized in 1905 by John A. Fleming in England. At that time Fleming was engaged in the development of a system of wireless telegraphy and obtained a patent on the use of the "vacuum tube" as a detector of high frequency electrical oscillations. This patent is one of the most fundamental patents in the entire history of electron tube development. From this rectifying property also is derived the English term valve to designate the electron tube.

The arrangement shown in Fig. 8 provides half wave rectification. Where it is desired to produce full wave rectification, two tubes, or a modified form of tube having two plates may be used in circuits such as shown in Fig. 10. Although two tubes are used at A only one is in use at one time. While the plate of one is charged positively the plate of the other is charged negatively; thus, while one tube is conducting the other is inactive. The instantaneous directions of currents in the circuit for two successive halves of the cycle are shown in Fig. 11.

We have now explained the first simple property and application of the electron tube. Surely there has been nothing about it that might be called difficult. Nothing that has required any profound knowledge of physics or electrical theory. Indeed, the whole thing is quite as easy to understand as is the action of a commutator on a motor.

In the articles that follow, more involved properties of electron tubes will be discussed but if one understands the fundamental principles here outlined, no trouble should be experienced in grasping at least some of the more complex principles.

The tube we have considered is the diode—having only two primary elements. A tube with three elements is called a triode and one with five a pentode.

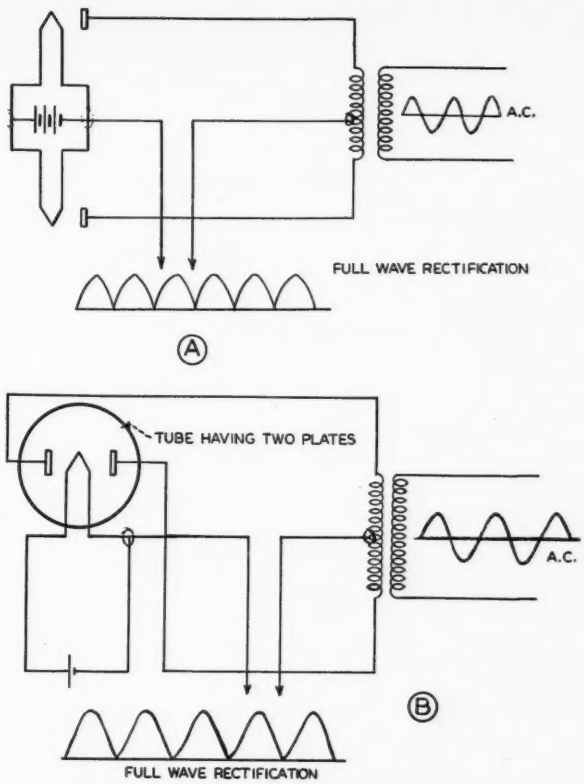


Fig. 10. (A) Diagram showing two diodes connected to give full wave rectification. (B) Diagram showing how a single tube with two plates can be used to give full wave rectification

All tubes can be classified according to these general family names, diodes, triodes, tetrodes (a 4 element tube), pentodes, etc. However, there are many other names by which tubes are known. Thus, there are phanatrons, thyratrons, pliotrons, kenotrons and dynatrons, and there are grid glow tubes, cathode ray tubes, X-ray tubes, high vacuum and gaseous tubes, etc., and new types are continually making their appearance.

This variety of names is naturally confusing to the lay mind or to the electrical engineer not directly concerned with tubes, but it need cause no confusion if we consider tubes according to their function rather than by name—according to what they can do. Thus when we speak of an X-ray tube there can never be any doubt as to what is meant, though an X-ray tube might also be called a diode.

So in the beginning we shall not concern ourselves with the technical names which have been applied to various kinds of tubes but will endeavor to explain their action and indicate their purpose simply and directly as we come to them.

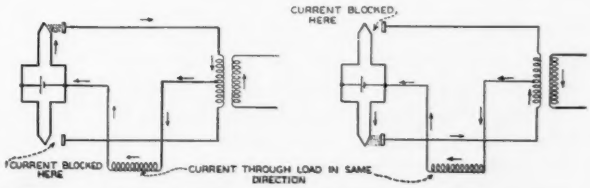


Fig. 11. Diagram showing the instantaneous direction of current in various parts of a full wave rectification circuit during successive halves of the cycle

A Brush Problem

By KERMIT B. HOFFMAN

SOME TIME AGO I received a telephone call from a friend who had recently been transferred to the operating division of our company, a large eastern utility.

"Sounds like you're having trouble," I replied after listening to the strained voice at the other end of the wire.

"It is to me," came the reply. "If you're free for a little while I'll come over and explain."

"Okay," I said and heard a sigh of relief. As I sat waiting I realized why Bill was worried. He was not so young any more, new to the operating game and probably nervously anxious to make good. And under that kind of stress one usually forgets to use horse sense in his daily problems.

"Gosh, I'm glad you're free," he said when he came and sat down in my office. "It's something that's happened on one of our machines that has me stumped, and I want to get it fixed before the District Supervisor comes around. It's a brush problem."

"Brush problem, eh. Well, suppose you tell me about it."

And so Bill told his story.

About two months ago the old set of graphite brushes were replaced by graphitized carbon brushes. The commutator had been stoned, chamfered and undercut and was put in first class shape before the new brushes were installed.

The graphite brushes had been removed because they had given short life (running hours) and also had the tendency to gouge the commutator thus requiring frequent undercutting resulting in high maintenance.

The electrographitic brushes had worked like a charm compared to the graphites. They gave to the commutator a chocolate brown color instead of the bright raw-metallic appearance. The wear of the brushes was uniform around the commutator and of a negligible amount.

Then suddenly tracks of the raw copper showed and soon the commutator had the appearance it did when graphite brushes had been operated.

Since I could offer no definite explanation I suggested that we go over and look at the machine. Arriving at the plant a few minutes later, I went over to the unit in question and saw the bright polish of the commutator under the glow of incandescent lamps.

"How about the load on the machine," I asked, "has it changed to any considerable extent?"

"No. It carries full load at all times. The load hasn't been changed since these brushes were installed."

I jostled a few brushes on different arms. They moved freely and there was no evidence of dusting.

"You won't find any sticking brushes. I went over them all. And we clean them every night with compressed air so no dirt can stick in the holders."

"How about brush pressure?"

"Checked all brushes and they're within a half pound average of the pressure the brush manufacturer specified."

It was then I began wondering whether this was going to be such an easy case after all.

"How about the winding? Did the 'Maintenance Crew' solder any joints, put in new armature coils or change any of the machine characteristics when they worked on it?"

"Nope. I checked with the fellow that had charge of the job and he says all they did was dress up the commutator."

I bent low and looked at the toes and heels of the brushes.

"Good commutation," I remarked. "Not a spark at full load."

"You'll find that around the whole commutator," Bill assured. "I even snapped out the lights and couldn't find a pin spark."

"How about the setting of the brushes? Are they on electrical neutral?"

"I checked that, too, and found them where the maintenance crew said they were originally, right on electrical neutral. I also checked the spacing between the brushholders and found it equal around the commutator."

I looked around. "How about that window," I said, picking at any reasonable straw. "If you operate with it open dirt could come in, get under the brushes and cause that condition."

"But the window is never opened," replied Bill, vigorously.

"Can you spare the machine for a few minutes?"

Bill nodded.

"Then it boils down to this," I concluded as the machine lost momentum when the switches were tripped. "The characteristics of the unit have not been changed. The operating conditions remain the same. So the only other thing that could change are the brushes."

I pulled quite a few out of the holders and studied the faces. Finally I held two up.

"Well, there's your answer," I said.

"What do you mean?" Bill asked excitedly. "You've found out what's wrong?"

"I believe so. Study the faces of those two brushes and tell me if you notice any difference. Don't look for anything radical or startling, merely a slight difference."

"All I can see is that one is a little shinier than the other," said my friend after a few minutes intent scrutiny.

"Exactly. Now you get a new brush that's never been used and you'll find it a dull appearance. That's the way they should be and then they will put that chocolate-brown skin on the commutator you've been talking about. But in this brush set came a few brushes from a batch in which the abrasive concentrated, this happens once in a while, at a certain point in the brush. The brushes went along fine and acted like ordinary brushes until they wore down to this abrasive strata. Then they started tearing the skin and gouging the

commutator. And if you'll check each face you'll find the shiny ones staggered in such a way as to cover the complete commutator, which resulted in a commutator that looked as though you were operating the old graphite brushes.

"I suggest you sandpaper all the brush faces and operate the machine for a few days and watch the commutator. If I'm correct your brush troubles will be over for this machine."

A week later I received a call from Bill advising me I should see that commutator now—"why it has just the most beautiful chocolate color——."

The Ice Plant as a Heater

Reversed Refrigeration Provides Year Around Air Conditioning for Virginia Electric & Power Co., at Williamsburg, Va.

REVERSING THE REFRIGERATING CYCLE for heating is not new, having been suggested back in 1852 by Lord Kelvin but it is still a distinctly novel application of refrigeration and air conditioning and the number of actual installations of these systems is small.

To understand this, one must consider a refrigerating system as a means of pumping heat from a colder place to a warmer place. Thus a refrigerating system can be built to pump heat from the cold outdoor atmosphere into the warm interior of a building. Added to this heat is the heat equivalent of the electrical input to the compressor motor, because this is dissipated to the heating water and the air of the room housing this equipment. These two heat components add up to a total considerably greater than the actual energy input to the compressor motor, resulting in a heating system which, in terms of heat units, is more than 100 per cent efficient.

To use the same refrigerating system for heating in winter as is used for cooling in summer is obviously a promising proposition to air conditioning engineers. Certain limitations to the heat pump are recognized and admitted. The main one is that its efficiency decreases in winter with a lowering of outside temperatures, so that it works at a minimum efficiency when heat is most needed. However, this problem can be solved, electrically, through the use of electric resistance heaters.

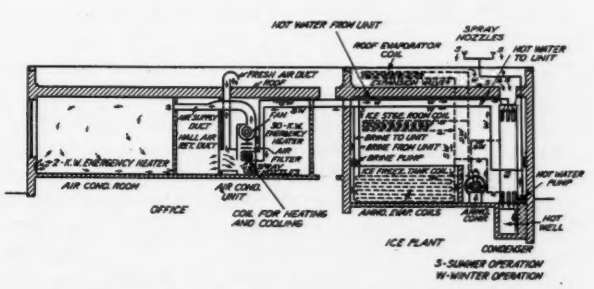
The Virginia Electric & Power Co., at Williamsburg, Va., operate in conjunction with their power plant, an ice making plant, and in the design of a building they laid out a York refrigerating system which would provide a total of 38.3 t. of refrigeration for ice making and air conditioning. As now installed the system performs these operations and in addition heats the building in winter by reversing the refrigeration cycle as a heat pump. This arrangement permits the company to make effective use of the condenser water heat otherwise wasted by an ice plant in the winter. The air conditioned rooms have a total area of 2,800 sq. ft., and contain 30,800 cu. ft. of space.

Operation of the system can best be visualized by a study of the accompanying flow diagram. Solid lines indicate a flow of water or brine, and broken lines show the flow of ammonia. The letter S indicates the circulation of a fluid in summer, while W indicates a flow in winter, and SW shows pipes in which the flow is continuous in all seasons. Equipment includes two vertical type standard York ammonia compressors, a York ice freezing tank, shell and tube condensers, and a special York central station air conditioning unit.

In summer the refrigerating plant makes ice and refrigerates the ice storage room as well as cooling the air conditioned rooms, the heat extracted from these sources being discharged to the outside atmosphere by means of the spray pond on the roof of the building. For winter operation, certain valves are turned so as to change the flow in certain portions of the system. Thus, instead of cooling the hot condensing water from the ice making and storage system by means of a spray pond, this hot water is circulated through the air conditioning coils in order to heat the building.

Because of the fact that the heat extracted from the ice freezing tank and storage room is not alone sufficient to heat the building in the winter, a third evaporator coil is installed on the roof. Here ammonia is evaporated, the heat removed from the cold outdoors being pumped indoors through the refrigerating system and eventually in the form of an increased supply of hot condensing water is delivered to the air conditioning coils.

Winter temperatures are automatically maintained



Arrangement of equipment for reversed refrigeration cycle

by two thermostats. The first is set for a temperature below 70 deg. F., and starts a 20 g.p.m. pump, operated by a ¾ hp. motor which supplies hot condensing water to the coils in the central type air conditioning unit. If the air temperature continues to fall and the heat given off by the condensing water being circulated through the air conditioning coils is unable to maintain a room temperature above 68 deg. F., the second thermostat turns on a 30 kw. electric heater which is built into the air conditioning unit.

Finally, if a high temperature is desired in any of the rooms for some special reason, a thermostat in that room is provided to turn on a small electric wall type heater. There are 10 of these booster heaters installed in the building, each consisting of a 2 kw. heating element and a low velocity fan. During the past winter season it was found that these auxiliary heaters were seldom used.

Combustion Control

(Continued from p. 228)

other extreme. There is normally a small flow of air through the throttle opening and out the bleed opening to atmosphere at all times.

When the particular boiler is operating parallel with others in response to the master controller, its load adjustment valve may be employed to reduce its output by any desired amount as compared with the other boilers. In the "individual" position of the transfer valve this valve is the sole means for determining the loading pressure applied to the controllers at the corresponding boiler.

Complete control of all boilers is thus accomplished from a central position. All boilers can be operated as a unit each taking a full and proportionate share of the load swings or the maximum load on any one boiler may be limited by means of the load adjustment valve. Any or all boilers may be operated under constant or base load by turning the transfer valve and the load carried can be varied by means of the load adjustment valve. By turning the selector valve to "push button" all control drives are locked in position and individual drives can be moved in either direction by push buttons.

This flexibility makes provision for complete push button control when putting a boiler on the line or under abnormal operating conditions. In case of electric power failure the unbalanced dampers are locked in position and cannot move until moved manually by the operator. In case of air failure an interlock cuts out automatic control, thus allowing the boiler to operate at the existing load and subject to pushbutton operation.

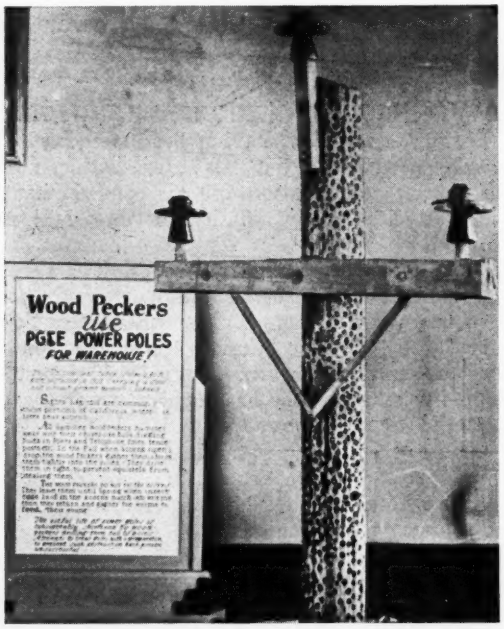
The type and number of other interlocks employed are subject to variation with the particular application. When firing fuels in suspension (pulverized coal, oil or gas) interlocks are ordinarily provided to prevent improper fuel-air ratio at the maximum limit of draft and at the minimum limit of fuel supply. Thus, when the boiler outlet damper is wide open, an interlock prevents further increase in fuel supply and at the low limit of fuel supply, another interlock prevents further reduction of draft or air supply.

Just "A Pain in the Neck"

By C. W. GEIGER

TO MOST persons woodpeckers are truly admirable birds. They are intelligent, industrious and thrifty. Above all, they are good providers and see to it that their family larders are well stocked the year round.

To Pacific Gas and Electric Company engineers and linemen, however, woodpeckers are just "a pain in the neck." The reason is that the birds persist in drilling power line poles full of holes and using them as warehouses for their supplies of food. Day after day throughout the summer they drill away with their chisel-like bills—hundreds of holes to a pole. In the fall they gather acorns and force them into the prepared holes; force them in so tightly that the squirrels, who like them immensely and steal them whenever



possible, have learned it's a waste of time to try to raid these outdoor cupboards.

Incidentally, the woodpeckers do not eat the acorns. They leave them in the holes in the poles until spring when warm weather hatches little white worms from insect eggs laid in the acorns months before. Then they return and gather the worms to feed their young and satisfy their own appetites.

It isn't surprising that power engineers and linemen consider woodpeckers a pest. The perennial drilling greatly shortens the life of poles—and replacing poles is both costly and bothersome.

For years Pacific Gas and Electric Co. engineers have been working on the problem of eliminating this trouble. They have tried any number of protective preparations, but the birds practically sneered at all of them. So they're still racking their brains—and still cussing the woodpeckers.

The accompanying photo shows a Pacific Gas and Electric power pole which woodpeckers drilled full of holes. It was taken from a power line between Modesto and Oakdale, California.

Operating Code *for* Modern Plants

Sections IV, V and VI of the Operating Code for the power plant of Hiram Walker & Sons, Inc., Peoria, Ill.

PREVIOUS SECTIONS covered general instructions to boiler operators, starting the boiler on gas and changing from gas to pulverized fuel. Sections below cover starting the boiler on pulverized fuel, loss of ignition and operation of soot blowing equipment. The plant referred to has 250,000 lb. per hr., 250 lb., 500 deg. F. bent tube boilers with air heater, forced and induced draft fans, water cooled furnaces and combustion control. Pulverized coal is supplied from two 10-t. and one 3-t. pulverizer and natural gas is available as standby fuel.

This operating code was compiled by W. F. Biggs, power engineer of Hiram Walker & Sons, Inc., Peoria, Ill., for the guidance of power plant operators, primarily to promote operating efficiency, fix responsibility and prevent accidents. It is divided into ten sections: I, General Instructions for Boiler Operators; II, Starting boiler on gas; III, Changing from gas to pulverized fuel; IV, Starting boiler on pulverized fuel; V, Loss of ignition; VI, Soot blowing; VII, Shutting down boiler; VIII, Fires in equipment; IX, Turbine room procedure; X, Starting water softener.

Sections I, II and III appeared in the March issue, page 158, under the title "What Would You Do?" The remaining sections, VII, VIII, IX and X will appear in the next issue.

IV. STARTING BOILER ON PULVERIZED FUEL

1. Make preliminary adjustments of air-flow in the burner line.

2. See that everything in connection with direct-fired unit is in operating order.

3. See that induced draft damper is closed.

4. See that forced-draft dampers at burner windboxes and secondary air ports are closed.

5. See that air-tempering and air-control valves for pulverizer air supply are closed.

6. Start the preheater motor.

7. Start the induced draft fan.

8. Start the forced draft fan.

9. Open the induced draft damper and adjust the furnace draft between 0.05 and 0.06 in. of water as required for each individual job. Hold this setting for several minutes before inserting the torch in the furnace.

10. Light the oil torch and see that it maintains the proper flame for lighting.

11. Start the pulverizer fan and open the valve in the burner line to be used for starting. Be sure the oil torch is burning after starting the fan.

12. Start the pulverizer.

13. Start the raw fuel feeder. Adjust the fuel feed so that the feeder will deliver about one-half the capacity of the pulverizer. Operate 1 min. to provide sufficient pulverized fuel to insure a rich fuel mixture and permit quick ignition. Longer operation without passing air through the pulverizer is likely to result in a choked pulverizer.

14. Slowly open the air control valve, which supplies air to the pulverizer, to the predetermined points. This should insure quick and good ignition which can be observed from a distance through an observation door.

15. Open the forced draft dampers at the burner windbox and the secondary air ports and adjust the induced draft and forced draft fans to suit operating conditions. The furnace draft generally should be adjusted to 0.02 in. Operation of the oil torch should be discontinued before the ignition of the pulverized fuel has become self supporting and stable.

16. If the pulverized fuel fails to ignite immediately, shut off the raw fuel feeder, pulverizer, pulverizer fan and the oil torch. Allow the furnace to clear itself of pulverized fuel. Failure to ignite is caused by a poor flame from the oil torch or too lean a mixture of pulverized fuel, caused by insufficient feed or too much air.

17. After the system is purged completely of the pulverized fuel, proceed as before with the exception that the fuel-air condition must be readjusted to give a richer pulverized fuel mixture.

18. When there is more than one pulverized fuel burner connected to the furnace and it is desired to place additional burners in service, the oil torch should be applied to each burner to be lighted. If the burner to be lighted is one connected to a pulverizer in operation, then the burner line valve should be opened very slowly to prevent any accumulation of the pulverized fuel, which may be in the burner line, from being in-

jected suddenly into the furnace. During this operation, the burner should be observed closely to be sure that the burner line is clear.

19. Careful observation of flame conditions should be made whenever adjustments are made and the induced draft and forced draft should be adjusted to provide good flame conditions in the furnace.

20. The temperature of the pulverized fuel and air mixture leaving the pulverizer must not exceed 150 deg. F. At this temperature, the high temperature alarm operates. The normal operating temperature will vary because of variations in raw fuel moisture and quantity of fuel pulverized, provided the quantity and temperature of the air supplied to the pulverizer remain constant. In order to keep the outlet temperature of the air within the desired limits, regulation should be accomplished by adjusting the tempering air entering the pulverizer and not by changing the quantity of air.

V. LOSS OF IGNITION

A. When Operating a Pulverized Fuel Furnace at Low Rating or on Active "Bank":

The cooler furnace usually results in a higher than normal percentage of unburned fuel loss and a likelihood of losing ignition. The loss of ignition usually results from fuel-air ratio variations so that precautions should be taken to obtain and maintain the proper mixture of fuel and air. The following precautions should be taken to prevent loss of ignition:

1. Operation should be at a sufficiently high rate to maintain ignition with a safe margin even resorting to intermittent firing if necessary.
2. The lighting torches should be kept burning during low rate operation.
3. The fuel feed should be continuous and steady during the firing periods.
4. The supply of air should be proportionate to the fuel supply and any change in the fuel or air supply should be made gradually and intelligently.
5. Sootblowers should not be operated during low rate operation to prevent sudden and uncontrollable changes in the air flow.

B. If Ignition Is Lost, the Operator Should Proceed as Follows:

1. Shut off the fuel feed immediately. This may be done automatically, or, manually by the operator who should have available means of observing the fire.
2. Do not increase the air flow through the furnace for clearing purposes but allow about a minute for the pulverized fuel to settle and clear the furnace.
3. Leave the air flow unchanged at low ratings. Relight the burners promptly by supplying fuel to the burners at a sufficiently high rate to give a rich mixture and sustain ignition with a good torch. Then, readjust the fuel and air to proper and stable conditions.

C. If Ignition Is Lost and Pulverized Fuel and Air Continue to Flow Unignited Resulting in Considerable Accumulation, the Operator Should Proceed as Follows:

1. Shut off the fuel feed.
2. Reduce the air flow to 10 per cent or less of the maximum rating. The air flow should not be shut off entirely since gases are probably being generated. These gases should be scavenged out of the furnace to avoid an accumulation and an explosion. The air flow should be maintained at this low rate to avoid disturbing the pulverized fuel which may be deposited on the furnace floor, boiler tubes, or throughout the setting. The air flow should be continued until it is certain there is no gas being generated and the fires are burned out or extinguished.

D. Handling Fuels in Furnaces.

Changes should be made gradually with full knowledge of the existing conditions whether firing with gas or pulverized fuel.

VI. SOOT BLOWING

1. Sootblowers should be operated only when the boiler is in normal service with a sufficiently high rate of combustion to insure a low oxygen content in the flue gases, or, when the furnace is cold. During the sootblowing operation, sufficient furnace draft should be available to prevent flare-backs or loss of ignition. The customary procedure is to increase the furnace draft well above the normal operating draft. When operating at the maximum capacity of the induced draft fan or the stock damper, this is accomplished by reducing the rate of combustion, during the sootblowing period. This excess furnace draft must be available whether the unit is being operated manually, or, with automatically controlled dampers which generally maintain the normal furnace draft during the sootblowing period as well as during normal operation.

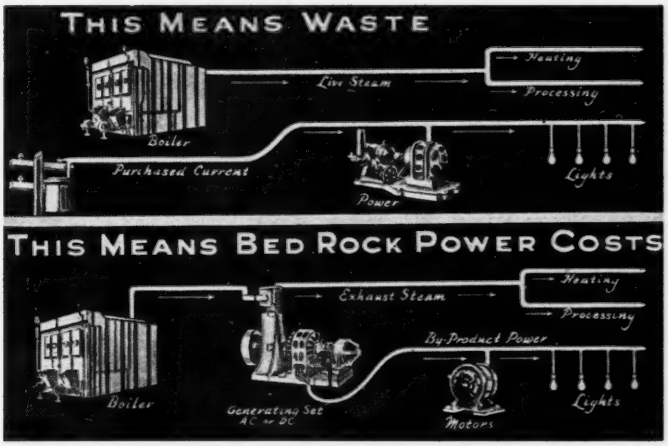
2. When burning low carbon, high volatile fuels which have a low ash fusion point, considerable slag is generally deposited in the boiler. In this case, the best results, for removing this slag with the least expenditure of energy, can be obtained when the boiler load has been brought down to either a light operating load or a bank. Under this condition, the decrease in the furnace temperature will allow the slag to chill and be more readily removed by the sootblower.

3. When burning high carbon, low volatile fuels, a large amount of carbon may be in the residue accumulating in the boiler setting. If this accumulation is on fire, operation of the sootblowers may result in an explosion. In this instance sootblowing should be done at times when there is a low oxygen content in the flue gases, and, the burner conditions are such that the sootblowing will not result in loss of ignition. If the sootblowing must be done when the boiler is out of service, first make certain there is no source of ignition in the furnace or setting which would result in an explosion. If the dust in the setting contains a highly combustible content, it is advisable to operate the sootblowers from rear to front and then from front to rear in order to minimize the amount of combustible dust blown into suspension.

(To be continued)

Actually, the earth rotates 366¼ times in a year but the reason there are only 365¼ days is because one revolution is cancelled by the earth's trip around the sun.

STEAM ENGINES *for* Industrial Service



Part I. Modernized steam engines provide cheap by-product power at low cost and give a reliable flexible drive

By F. J. VONACHEN

Troy Engine & Machine Co., Troy, Pa.

PLANTS IN PRACTICALLY EVERY LINE of industry, especially during the last few years when they were obliged to drastically reduce costs, have carefully investigated the modern steam engine for driving stokers, forced and induced draft fans, generators, refrigeration and air compressors, pumps, exhausters, blowers, ventilating fans, cookers, driers, presses, mixers, mills, line shafting, nitrating machines, core drills, balers, conveyors, and similar equipment. They have found from actual operating results that the modern steam engine can be applied to industry with substantial saving in plant operating cost, that its design has been completely modernized, and that its excellent characteristics assist plant operation.

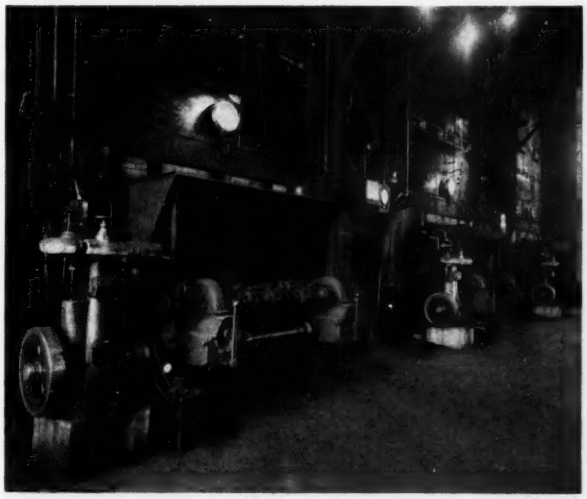


Fig. 1. Three engines used as stoker drives in a hospital power plant

In the last three years the following industries have installed modern steam engines for driving equipment noted above: Artificial gas, asphalt, brewing, ceramic, chemical, distilling, dredging, florists, food, glass, hospitals and institutions, hotels, ice, metal-working, mining, municipalities, oil and gas, packing, paper, public utility, railroads, railroad ferries, refining, rendering, retail stores, schools, scrap iron, states, steamships, steel, textile, in arsenals, in lighthouse tenders, universities and woodworking plants.

Let us consider the subject of the modern steam engine, in this case the single valve counterflow type, by two main divisions: first, thermal characteristics and low operating cost; second, types, sizes, design and mechanical operating characteristics.

Thermal Characteristics—Low Operating Cost

One of the important advantages of the modern steam engine is its generation of by-product power at very low cost. Steam at 80 to 150 lb. and higher pressures can be generated by a boiler at only slightly greater cost than at low pressures since most of the heat is used to change the water into steam and the additional amount necessary to raise the pressure is relatively small. This steam can be put through the steam engine cylinder, which serves as a reducing valve, to generate power and, depending on actual steam conditions, approximately 90 per cent of the heat in the initial steam will be present in the exhaust for heating and processing to take the place of live steam previously used. Thus the steam does double duty: first, in passing through the engine the steam generates power; second,

Table I. Actual plant survey for an engine driving stokers and fans

LOAD DATA
Maximum hp. required....42
Average hp. 29.4
Hours operation per year (if possible each month).....
24 hr. per da. × 365 da. per yr. = 8760
R.p.m. (normal) 300
Type of driven equipment—stokers and draft fan.....
Will additional capacity be needed for future expansion? No.
STEAM DATA
Pressure range, lb. ga....200
Quality ....Dry
Superheat ....None
Back pressure, lb. ga....2.5
Feed water temperature, deg. F....185
Cost of steam per 1000 lb....$0.50
Actual evaporation in boiler .....lb. of water per lb. of coal (.....lb. of water per 1000 cu. ft. of gas) (.....lb. of water per gal. of oil)
Cost of fuel $..... per ton (..... per 1000 cu. ft. of gas) (..... per gal. of oil).
PRESENT CURRENT AND HEAT COST
Tons coal used per year for heating and processing (if possible each month) .....
Cost of current including all demand charges.....
What part of steam used for heating and processing can be exhaust steam? All in 212 day heating season, none in 153 day non-heating season.
FIRST COST
First cost of engine installed....$1100.00
ANNUAL FIXED CHARGES
Depreciation—5% of $1100.00....$ 55.00
Average interest at 6%—$1100.00 × .0315.... 34.65
Maintenance—2% of $1100.00.... 22.00
Total $111.65
ANNUAL OPERATING COST
Determination of useful heat in exhaust:
Engine steam consumption = 1058 lb. per hr.
Heat in live steam = 1199 B.t.u. per lb.
Heat supplied engine = 1058 × 1199 = 1,270,000 B.t.u. per hr.
Radiation loss = 2% of total = 25,400 B.t.u. per hr.
Engine mechanical efficiency = 87.3%.
I.h.p. = 29.4 ÷ 0.873 = 33.7.
Heat equivalent of one—i.h.p. = 2545 B.t.u. per hr.
Heat converted to work = 33.7 × 2545 = 86,000 B.t.u. per hr.
Heat used by engine = radiation loss + work = 25,400 + 86,000 = 111,400 B.t.u. per hr.
Heat left in exhaust = 1,270,000 — 111,400 = 1,158,600 B.t.u. per hr. = 1,158,600 ÷ 1058 = 1097 B.t.u. per lb.
Available heat in the live steam = 1199 — (185 — 32) = 1046 B.t.u. per lb.
Available heat in the exhaust = 1097 — (185 — 32) = 944 B.t.u. per lb.
Per cent useful heat left in exhaust = 944 ÷ 1046 = 90.1%.
Steam cost for 212 da. heating season = 1058 × 24 × 212 × 0.099 × 0.50 ÷ 1000 = $266.00.
Steam cost for 153 day non-heating season = 1058 × 24 × 153 × .50 ÷ 1000 = $1940.00.
Total steam cost per year = 266 + 1940 = $2206.00.
Lubrication cost per year = $37.00.
Extra operating labor cost per year = none.
Total operating cost per year = 2206 + 37 = $2243.00.
TOTAL ANNUAL COST
Total annual cost = fixed cost + operating cost = 111.65 + 2243 = $2354.65.
This is equivalent to 2354.65 ÷ (29.4 × 24 × 365) = $.00915 per B.hp. per hr. or = $.0123 per kw-hr.

Table II. Plant survey form for a generating set

LOAD DATA
Maximum Kilowatt demand.....
Power factor.....
Kilowatt hours used per year (if possible each month).....
Hours of operation.....
Kilowatts lighting load.....
Type of lighting circuits.....
Number and size of motors.....
Characteristics of power current.....
How much additional capacity is required for future expansion? .....
STEAM DATA
Pressure range.....
Quality.....
Superheat.....
Back pressure.....
Cost of steam per 1000 lbs.....
Actual evaporation in boiler ..... lbs. of water per lb. of coal (..... lbs. of water per 1000 cu. ft. of gas) (..... lbs. of water per gal. of oil).
Cost of fuel $..... ..per ton (..... per 1000 cu. ft. of gas) (..... per gal. of oil).
PRESENT CURRENT AND HEAT DATA
Tons coal used per year for heating and processing (if possible each month) .....
Cost of all current including demand charges.....
If power company standby service is desired, what will be its cost?.....
What part of steam used for heating and processing can be exhaust steam?.....
Will steam required for heating and processing synchronize well with engine load .....

it retains approximately 90 per cent of the heat in the exhaust for heating purposes.

Cost of generating this by-product power consists of operating and fixed costs. Operating costs are about 10 per cent of the steam cost (the other 90 per cent of the steam cost being rightfully charged to heating cost), and lubrication cost. Fixed costs based on 20 yr. life are: interest on investment say six per cent; annual depreciation five per cent; annual maintenance two per cent. As a general rule, no extra operating labor is necessary with the modern steam engine. In spite of numerous items in the cost, the total is so low that steam engines usually pay for themselves in 6 to 12 mo. time by the saving in power cost.

Some processes require steam that is free from cylinder oil. Many steam engines are being operated entirely satisfactorily today without oil cylinder lubrication. With the cylinder properly constructed and glazed by the use of beeswax and graphite (a method that has been used for years in the highly critical marine field), it may be operated without any lubrication except possibly the introduction of a slight amount

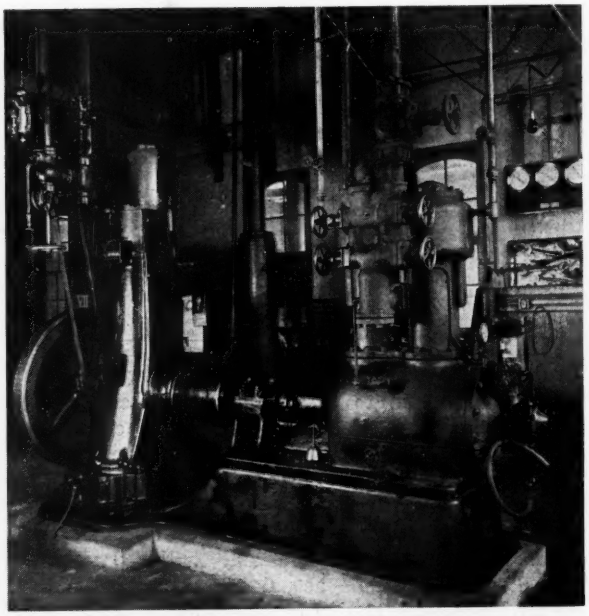


Fig. 2. Compressor drive in a brewery

of beeswax and graphite at infrequent intervals. A solution of colloidal graphite in distilled water, introduced into the cylinder by a special mechanical cylinder lubricator, has also been used with excellent success.

Since the water rate (steam rate) of the steam engine remains low throughout the entire speed range and even at high back pressure, the amount of exhaust best meets the requirements of the average plant and a good plant heat balance results. There is no limit to the amount of back pressure if there is sufficient initial pressure to produce the required power within the limits of practical cylinder bores. As this low water rate is closely maintained throughout the long life of the steam engine, the original plant heat balance is also maintained. This is quite important if greatest saving is to be obtained.

A good idea of the extremely low cost of steam engine by-product power may be had from the following actual plant survey of a 7 in. bore, 8 in. stroke vertical engine driving several stokers and a draft fan

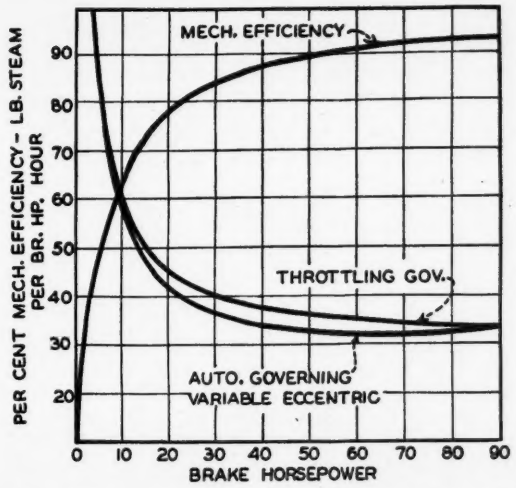


Fig. 3. Performance curve of an 8-in. stroke engine based upon 125-lb. saturated steam, 0 lb. back pressure ga. and 400 r.p.m. Correction factors for other conditions are given by Fig. 4 and the accompanying text

The following example is used to illustrate the calculation of water rates from Figs. 3 and 4: 30 b.hp. at 200 r.p.m., throttling governor, 175 lbs. ga. initial pressure, 100 deg. F. superheat, and 15 lb. ga. back pressure. Figure 3 is for 400 r.p.m., 125 lb. ga. staturated steam and no back pressure. Therefore to determine the water rate for any horsepower at a given speed, the horsepower must be converted to 400 r.p.m., horsepower being directly proportional to speed. For instance, 30 b.hp. at 200 r.p.m. would be equivalent to 30 × (400 ÷ 200) = 60 b.hp. at 400 r.p.m. The base water rate for dry steam for this engine with throttling governor and 30 b.hp. load at 200 r.p.m. would then be obtained from the above chart for 60 b.hp. at 400 r.p.m.; namely, 35.3 pounds per b.hp. per hour. Corrections are as follows:

SPEED—For each increase of 50 r.p.m. from the curve speed (400 r.p.m.), the base figure is decreased 1 per cent. For each decrease of 50 r.p.m. from the curve speed (400 r.p.m.), the base figure is increased 1 per cent. For example in this problem, 30 b.hp. at 200 r.p.m., the speed decrease is 400 — 200 or 200 r.p.m. The base figure of 35.3 should then be increased by 1 per cent × (200 ÷ 50) or 4 per cent and becomes 35.3 × 1.04 = 36.8.

INITIAL PRESSURE—To obtain the water rate for a particular pressure multiply by the factor for that pressure as given in Table III.

For example, if the initial pressure is 175 lb., the water rate becomes 36.8 × 0.939 = 34.5.

SUPERHEAT—The water rate should be decreased 1 per cent for each 10 deg. F. superheat. Therefore, if there is 100 deg. F. superheat, the figure becomes 34.5 × 0.9 = 31.1.

BACK PRESSURE—For example, for the back pressure of 15 lb. ga., the correction factor, from the chart, Fig. 4, is found as follows: 30 b.hp. at 200 r.p.m. is equivalent to 60 b.hp. at 400 r.p.m., the chart speed, which is full load for this particular engine. The correction factor for 4/4 load and 15 lb. back pressure from the above chart is 1.19. The figure then becomes 31.1 × 1.19 = 37 pounds per b.hp. per hr., which is the water rate of this engine with 30 b.hp. load at 200 r.p.m. when operating with 175 lb. ga. initial pressure, 100 deg. F. superheat, and 15 lb. back pressure.

QUALITY—If the steam is dry and saturated, or superheated as in the above example, there is no correction for quality. Should the steam contain moisture, this moisture would not be effective in producing power and the water rate should be divided by the quality; i.e., if the water rate before quality correction is 30 and the quality is 98 per cent, the water rate becomes 30 ÷ 0.98 = 30.6.

Figures in Table IV illustrate variation in water rates with engine size, the first figure in each case referring to a small engine (12 hp.), and the second figure to a larger engine (225 hp.), both equipped with fixed eccentric and thottling governor. These figures are reduced about 10 per cent if the automatic or flywheel governor for constant speed service, or the hand adjustable or variable eccentric with throttling governor for variable speed service, is used. All figures are at full load.

in an industrial plant as shown by Table I. Other plants desiring to make an engine survey can follow this general data sheet.

Table III. Pressure correction factors

Pressure	Factor	Pressure	Factor	Pressure	Factor
20	1.295	110	1.040	175	0.939
30	1.276	115	1.028	180	0.935
40	1.263	120	1.017	190	0.923
50	1.250	125	1.000	200	0.915
60	1.240	130	0.997	225	0.896
70	1.210	135	0,989	250	0.880
75	1.181	140	0.981	300	0.860
80	1.152	150	0.968	350	0.845
90	1.111	160	0.957	400	0.835
100	1.070	170	0.944		

If the cost of 1.23 ct. per kw-hr. as shown is compared with that of operating an electric motor under similar conditions with purchased current available at 2 ct. per kw-hr. including the demand charges, there would be a saving of $2523.00 per year, 51.7 per cent of the first cost, which would pay for the engine installation in less than 6 mo. and show an annual return on the investment of 229 per cent.

This particular survey is a good example of a plant that has use for exhaust during only a part of the year. If the exhaust is used the entire year as it can be in many plants and institutions, the cost is considerably lower. A general data sheet for survey work for generating sets is given in Table II.

Table IV. Effect of engine size. The first figures are for small engines, the second for large engines

Initial Pressure	5 lbs. B.P. 0° F. Supt.	5 lbs. B.P. 100° F. Supt.	15 lb. B.P. 0° F. Supt.	15 lb. B.P. 100° F. Supt.	50 lb. B.P. 0° F. Supt.	50 lb. B.P. 100° F. Supt.
80	52—38	46—34	58—42	52—37	78—56	70—50
100	48—35	43—31	54—39	48—35	72—52	64—46
150	44—32	39—28	49—35	44—31	65—47	58—42
250	40—29	36—26	44—32	39—28	59—43	53—38

While it is difficult to prepare charts to cover by-product power costs for various conditions, since practically every plant is operating under different requirements, it will be well to give a range of expected

(Continued on page 246)

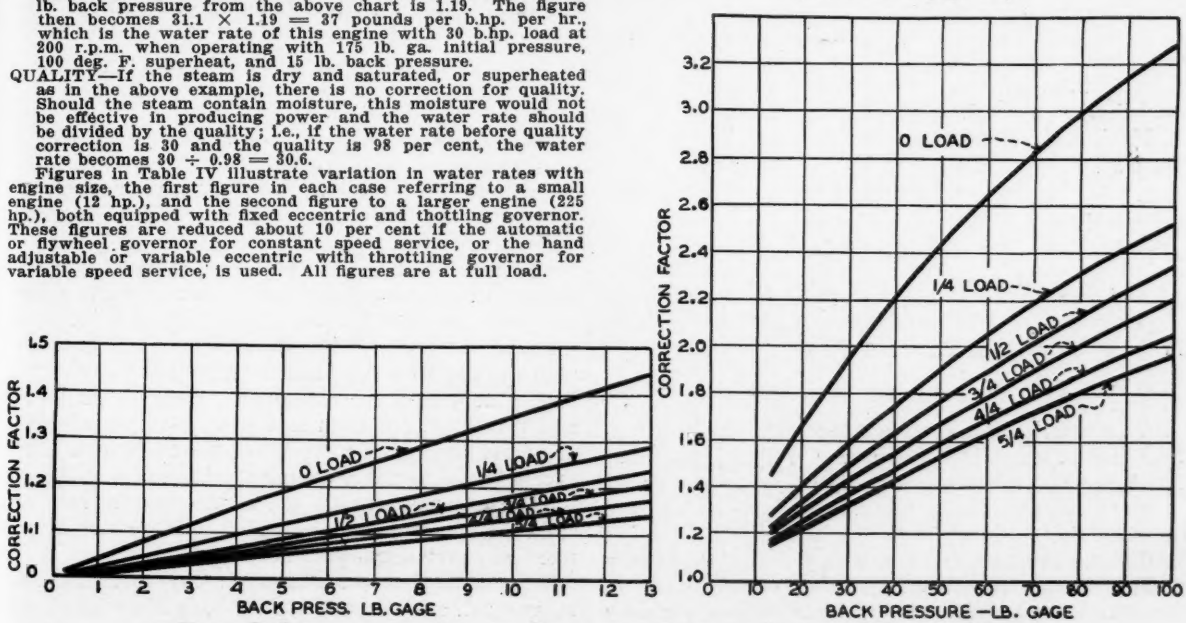


Fig. 4. Back pressure correction curves for a range of pressures from atmosphere to 100-lb. ga.

Case Studies in Power Economics

Conducted By
ZUCE KOGAN
Kogan Industrial Service
Chicago, Illinois

By an Investment of $30,000 in a New Turbine and a Change to Another Available Rate, a Manufacturing Company Was Able to Save $15,000 Annually

USUALLY, WHEN one contemplates an investment either to reduce his power cost or to improve his product, he will find several possibilities to accomplish the purpose, and naturally, an intelligent choice of the equipment or the method of making that investment is highly important. It is also advisable to have more than one view on the investment. This can be easily arranged by calling in one or more consultants in order to get a view which will possibly be free from bias and of a greater perspective. It will be found in many cases that one conceiving an idea may be so enthusiastic about it that he will not see its disadvantages by himself. It is only after being shown that he will see the folly of his ways.

The case we are dealing with now centers around a large manufacturing company which has a seasonal production and was purchasing power to the extent of $75,000 per year. Besides, this concern was housed in a large building, and during the winter months a temperature of 70 deg. was maintained throughout the building. This, of course, resulted in a large heating bill to the extent of $20,000 per year. For the purpose of heating they had three high pressure boilers.

Power was purchased from the local utility on a so-called yearly demand rate. This yearly demand rate is a rate by which the customer obligates himself to pay for the highest demand established during any one month of a 12-month period. In consideration therefor the utility naturally reduces the unit charge per kilowatt demand.

Having a potential source of power in the high pressure steam, this concern felt, and rightly so, that they could generate a portion of their power and use the exhaust steam for heating purposes. It was the contention of the chief engineer of this concern to install a 1000 kv-a. non-condensing engine alternator set and thus be able to use the exhaust steam for heating purposes. The investment involved was something in the order of $65,000.

Rate Structure Examined

They overlooked, however, one thing in the structure of the rate. Since they were purchasing power in large quantities, their energy rate per kilowatt-hour of over 300,000 kw-hr. per month amounted to approximately 0.3 cent. That meant that the utilization of the exhaust steam to remove a portion of the energy from their monthly electric bill, which would naturally be at 0.3 cent per kw-hr., would bring about a very small reduction in their electric bill, because the fuel cost alone would be slightly over 0.1 per kw-hr., not to speak of fixed and operating charges.

As far as the reduction in demand is concerned, the generation of power during the heating season would not have meant a great deal because the heating season was a slow period of production, and the demand on which they were billed was established in one or two of the summer months. Hence, any reduction in the demand, which would naturally be a result of power generation, would have no effect on their billing. In other words, this arrangement meant a large investment with little returns.

After surveying the plant another possibility was found which was finally carried through with good results.

In their plant they had three a.c. to d.c. motor generator sets. One was 1000 kw., one 750 kw., and one 300 kw. The 750-kw. unit was used practically all the time, the 1000-kw. and the 300-kw. units being used for standby and low loads respectively. These motor generator sets were used to supply a group of d.c. variable speed motors.

The fact that they had a motor generator set immediately pointed out the possibility of reducing the investment; i. e., eliminating the necessity of purchasing the generator part of the engine's generator set which they contemplated at a cost of $65,000. As pointed out previously, however, this reduction would still not make it a paying investment inasmuch as the actual saving was small.

We had to find, therefore, a means of reducing the maximum demand. Naturally, a simple method would have been to operate the boilers during one or two months in the summer time. Since it was not definitely known, however, during what month this demand might be established, it meant keeping the boilers going all the time and employing a crew for it, an expenditure which would make a considerable inroad in the saving.

To operate on the monthly demand rate was also out of the question, because the unit rate per kilowatt was very high, and even if they were to generate, the high cost during the summer months would eat up the savings brought about during the heating season.

The only thing that was left was another rate, the so-called limited hour rate, which calls for the curtailment of power during the hours of 4:30 to 7:30 in the months of November, December, January, and February; i. e., during a portion of the heating season. A difficulty arose, however, because they were operating

practically 24 hr. a day with some reduction in power after 5:00 in the evening.

In order to get a definite picture of the daily load, they obtained permission for us to study the records of their demand rates in the files of the local utility. From these records we found that in spite of the fact that they had been operating 24 hr. a day, their power dropped sharply at 5:00, and their power demand from then on amounted to one-third of their day demand.

Return Power to Lines

This fact pointed out that the generation of power would enable this concern to reduce their electric bill considerably with a minimum of investment (1) by being able to take advantage of the cheaper rate on their demand charge offered by the utility through generation during the evening hours, (2) by reducing the actual maximum demand during the six months of heating season, and (3) by obtaining energy at a lower cost. All the above were to be accomplished by the mere interconnection of a 1000-hp. turbine to the 750-kw. motor generator set to drive both the d.c. generator and the synchronous motor, the latter as an alternator. The object of the latter arrangement was to take away the uncertainty of the d.c. requirement. They needed d.c. power intermittently and they could use a.c. power all the time. Now, then, when the steam for heating purposes could generate more power than is required for d.c., the alternator was to be arranged to return power to the utility's lines. When the steam supply was not enough to generate all the d.c. power, the smaller 300-kw. motor-generator was to help out in conjunction with the engine generator alternator set.

Working Hours Changed

The most important thing in this arrangement was the shift in the hours of operation, arranging the day shift to start a half-hour earlier so that instead of the drop in power requirements mentioned above at five o'clock, the drop would occur at 4:30 p. m.—a thing which would bring them closer in line with the requirements of the utility for the cheaper rate discussed above. Since the necessity for power curtailment occurs during the winter months, the steam used for the generation of power could be utilized for heating purposes. Hence, there is practically no additional cost of steam for generation purposes.

This arrangement showed a possibility of saving annually $15,000 of their electric bill with an investment of $30,000 for the 1000-hp. turbine and incidentals of the installation.

After some argument with the utility, this concern was permitted, by installing proper controlling devices, to return the a.c. power into the utility's line generated by erstwhile synchronous motor of the 750-kw. motor-generator set. On the turbine was installed a regulating valve which permitted only an amount of steam to enter into the turbine to generate power to the extent of heating necessary.

In this manner, by taking advantage of the operating characteristics of the plant, the equipment available, and the rate offered by the utility, it was possible to reduce the investment contemplated and bring about a larger saving.

Floods, Pittsburgh and Power

DURING THE RECENT FLOOD the Duquesne Light Co. maintained almost complete electric service in Pittsburgh until shortly after 4 o'clock Wednesday afternoon, March 18, at which time the company was forced to take its last plant (the Colfax Power Station) off the line. On the following day, Thursday, every effort was made to obtain service through the company's interconnections, and by Thursday night service was being rendered in the amout of approximately 35,000 kw. By Friday night additional sources of energy had been made available and service of approximately 70,000 kw. was being furnished to essentials such as police, hospitals, communication systems, etc.

On Saturday, March 21, the company was able to put in service turbine No. 3-B of its Colfax power station and thereby increase the amount of energy available to approximately 100,000 kw. On Monday, March 23, the Reed power station was brought back into service to the extent of 40,000 kw., but due to large increased demands for service in the territories of neighbor companies, the energy available through interconnections had been reduced about 10,000 kw.

On Tuesday, March 24, it was expected that within the next day or two it would be possible for the company to bring into service two additional turbines of 70,000 kw. combined capacity at the Colfax power station and to increase the output of the Reed station to its full capacity of approximately 60,000 kw. With this program accomplished, the company would be in position, from the standpoint of capacity of its power stations, to furnish something over 160,000 kw. to its customers, and it was expected that before the end of the week the company would be able to bring into service the remaining capacity of its Colfax station with the exception of turbine No. 3-A, 30,000 kw. capacity, which is out of service due to routine overhaul. At the time of the shutdown demand on the system approximated 260,000 kw. Therefore, by the latter part of the week, it was hoped, the full capacity of the power system, with the exception of the old Brunot Island power station and turbine No. 3-A at Colfax, would be back on the line.

On Saturday night, March 21, the company was rendering electric service to approximately 80 per cent of its domestic customers and street lighting service of approximately the same percentage. Naturally this was accomplished by a great deal of rearrangement of distribution facilities and a great number of temporary expedients had to be adopted. Street car service was partially restored by Saturday night. By Monday, March 23, a two-thirds capacity schedule was in force on lines of the Pittsburgh Railways Company, with 269 trolley cars in operation.

Gas service, supplied by Equitable Gas Company, was not interrupted except in flooded districts where, because of the nature of the emergency, the company temporarily discontinued the service itself.

Primary Treatment *of* Feedwater *by* Phosphate

This new type of feedwater treatment consists in softening all of the make-up water with phosphate prior to its admission to the boiler feed system

By CHARLES E. JOOS

Manager, Water Purification Division, Cochrane Corp.

PHOSPHATE as a reagent for softening water before feeding it to boilers offers great advantages which heretofore have not been brought to the attention of the public. Early literature on feedwater treatment frequently refers to trisodium phosphate, soda ash, caustic soda and lime as suitable reagents for water softening and likewise trisodium phosphate has long been recognized as a suitable ingredient of boiler compounds, but the early literature does not reveal that the engineers and chemists understood, or followed such practices that permitted attaining the full use of phosphate for this purpose.

Phosphate as a supplementary treatment of boiler feedwater to follow softening by the well known lime-soda and zeolite water softeners is extensively used in the modern high pressure plant and when fed directly to the boilers gives splendid results from the standpoint of protecting boilers from scale. Trouble has been experienced, however, with deposit in feed lines when monosodium phosphate was fed into the suction of the feed pump, the calcium carbonate hardness being precipitated as calcium phosphate due to its lower solubility.

The supplementary phosphate treatment precipitates in the boiler the residual calcium still present in any pre-softened water to form a non-adherent sludge. The system, however, involves the complication of feeding phosphate to boilers with a high pressure feed pump and manually controlling the rate of feed to the several boilers. Even when the phosphate is intermittently fed directly to the suction of the boiler feed pumps there is no assurance that it will be distributed among the boilers in the same proportion as the total quantity of makeup.

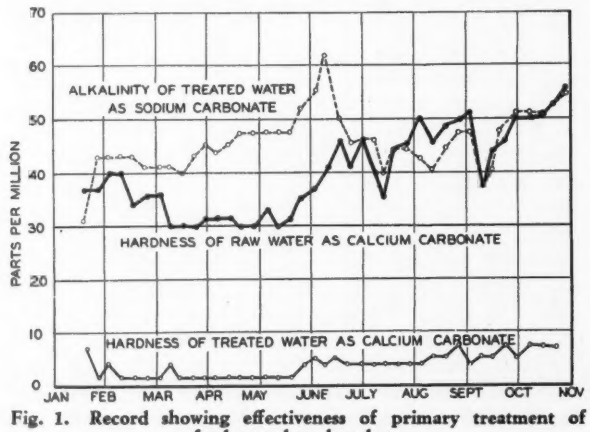


Fig. 1. Record showing effectiveness of primary treatment of feedwater by phosphate

These objections are overcome by softening all of the make-up water with phosphate prior to its admission to the boiler feed system, i.e., giving the water a primary treatment with phosphate as compared with a supplementary phosphate treatment.

The treatment consists essentially of using trisodium phosphate and caustic soda, or other forms of sodium phosphate, depending upon the character of the water to be treated, to precipitate calcium in the hot process softener sedimentation tank. The process depends upon the following chemical reactions precipitating the calcium as phosphate and the magnesium as hydrate.

Chemical Reactions

(1) $3CaCO_3 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3Na_2CO_3$

(2) $3CaSO_4 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3Na_2SO_4$

(3) $MgCO_3 + 2NaOH \longrightarrow Mg(OH)_2 + Na_2CO_3$

(4) $MgSO_4 + 2NaOH \longrightarrow Mg(OH)_2 + Na_2SO_4$

(5) $MgCl_2 + 2NaOH \longrightarrow Mg(OH)_2 + 2NaCl$

Since the phosphate is uniformly proportioned to all the make-up, the excess of phosphate in the softened water is easily determined by test; thus the desired excess of phosphate in all of the boilers is easily assured without the need of testing the water in the individual boilers.

Actual application of the method to a number of low and high pressure plants during the past 5 yrs. has shown the reactions to be so complete that a water of what is commercially known as "Zero Hardness" is obtained. There were no ill effects from the standpoint of deposits in feed lines, economizers, and other feedwater equipment. The first plant was placed in operation in 1931 and the record of performance has been so satisfactory that the method of treatment has already spread to other plants and is now being contemplated for many new high pressure installations.

One of the most interesting applications is in a plant using Delaware River water as their source of make-up. The plan is of the modern high pressure high rating type operating two Riley boilers at 450 lb. per sq. in.

each normally designed for 300,000 lb. per hour. The raw river water is sufficiently low in hardness to remove the necessity of pretreatment with lime and soda; it is accordingly treated directly in the hot process softener by trisodium phosphate and caustic soda. A typical analysis of the raw water is indicated below:

	Parts per Million
Calcium carbonate	19.0
Calcium sulphate	14.0
Magnesium carbonate	16.0
Silica	6.0
Iron oxide and alumina	2.0
Sodium sulphate	14.0
Sodium chloride	13.0

Figure 1 illustrates data taken from operating records showing the effectiveness of the treatment.

During a full year's use of the primary treatment careful observations have been made and records kept which have demonstrated that no after deposits occur in the feed lines, pumps or in economizer sections. The boilers have been kept in an exceptionally clean condition.

Boiler water alkalinities have been maintained comparatively low and consistent with what would ordinarily be carried with the lime-soda supplementary treatment. Records of chemical cost show that the primary treatment is no more expensive than the lime-soda supplementary phosphate treatment with the advantages of more complete removal of calcium and the elimination of high pressure phosphate pumping and proportioning equipment. In this plant the boiler water is tested for phosphate, in addition to the regular tests of the treated water, and it has been found that phosphate concentrations could be maintained more uniform than with the supplementary treatment.

It is interesting to note that this plant is now using by-product phosphoric acid in combination with caustic soda as the treating chemicals, resulting in low chemical costs.

A central heating plant using a soft and corrosive city water supply adopted the phosphate treatment method in 1931, with splendid results. The plant operates with 100 per cent make-up, treated through a 40,000 g.p.h. deaerating hot process softener. The raw water contains a total hardness of 30 p.p.m. which is reduced to 4 p.p.m. as a result of this treatment.

A well known public utility operating with jet condensers and, therefore, 100 per cent make-up is using the treatment in their 120,000 g.p.h. hot process softener for boilers operating at 275 lb. per sq. in. Results have been highly satisfactory. The raw water is from a mountain stream containing at times considerable silt in suspension.

Soft colored waters containing tannins and which for that reason are difficult to treat by conventional methods have been treated efficiently by this method. The addition of lime and soda to such waters is rarely effective in reducing the hardness, due to the fact that tannates hold calcium in solution. The effluent from a hot process lime and soda softener treating such colored waters is often higher in calcium than the incoming raw water. In the application of the primary phosphate treatment to such waters the practice followed is first to coagulate and precipitate the bulk of the tannates and organic matter, removing its color, and then follow with the phosphate treatment in a hot process softener. In a Wisconsin paper mill subject to a severe condition of this character the treatment with

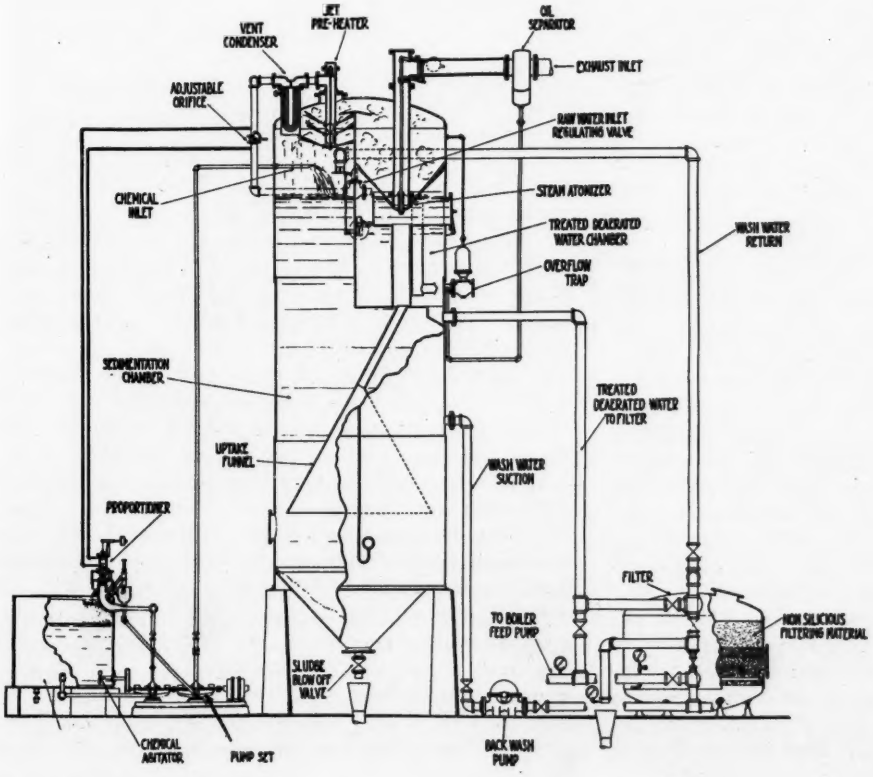


Fig. 2. Equipment suitable for primary treatment by phosphate

phosphate has been found to be entirely satisfactory, after lime soda treatment alone had been tried and proven inadequate. The analyses of the raw and treated waters indicates practically complete removal of calcium and magnesium as shown by the following:

	Parts per Million	
	Raw	Treated
Calcium carbonate	...	0.5
Calcium sulphate	36.7	...
Magnesium carbonate	7.2	0.4
Sodium carbonate	...	42.8
Sodium sulphate	7.1	73.2
Sodium chloride	8.2	8.2
Sodium phosphate	...	15.8
Magnesium sulphate	19.9	...

Method of Control

Figure 2 illustrates the equipment for carrying out the primary treatment by phosphate which consists of the conventional chemical feeding equipment, the hot process softener sedimentation tank and filter with back-wash connections. A unique feature about the design illustrated is that it incorporates deaeration as part of the heating process. This is accomplished by thoroughly atomizing the water after it has been preheated by having this flow onto high velocity steam jets which issue from the steam atomizer, all of the steam entering the system passing through this atomizer, thus bringing about minute dispersion of the water so that the last traces of oxygen are removed. There is very little steam condensed in the atomizing chamber, all of which passes to the left side of the sedimentation tank and condenses in the jet preheater and the vent condenser where the gas is ultimately removed to the atmosphere.

The chemicals are proportioned and fed by the proportioning equipment of the hot process softener. The chemical addition is governed by two factors, the pH value and the excess trisodium phosphate of the treated water after filtration, i.e., both of which are determined by the usual colorimetric methods. An excess of phosphate of approximately 5 to 10 p.p.m. of Na_3PO_4 and a pH value of 8.5 to 9.0 is required for the best performance.

Application of Treatment

The factors limiting the application of primary treatment with phosphate without pretreatment with lime and soda are the initial alkalinity of the waters and its total hardness. It will be seen from reactions (1) and (3) that the by-product of sodium carbonate is produced in proportion to the bicarbonate of the raw water, so it is obviously essential to limit its employment to these cases when the increase in sodium carbonate content of the treated waters will not be objectionable. Also, if a water is high in hardness cost of chemicals makes it more economical to resort to lime-soda, supplementary phosphate treatment.

The use of two water softening systems for the treatment of high hardness waters, first by the inexpensive lime and soda process and then followed by the primary phosphate process is not ordinarily justified in view of the good results being obtained in modern high pressure boiler plants by lime and soda with supplementary internal phosphate treatment. Where a water softener, however, is already installed but not adequate in its effectiveness to meet the requirements of a modern high pressure plant, such a softener can advantageously be followed by a hot process softener in which phosphate is fed as a softening reagent. Several such installations have already been made as additions to existing cold process softeners with excellent results.

This method is particularly well adapted to those waters that have a hardness considered too high for internal treatment and yet too soft for treatment with lime and soda ash, filling a gap that has long existed in the field of feedwater conditioning. It is ideally suited to the treatment of soft turbid waters because of the simplicity of the equipment required for clarification and softening. The completeness with which calcium and magnesium are precipitated invariably obviates the need of additional coagulant.

Where applicable, the primary treatment by phosphate offers a number of advantages, briefly stated as follows:

(1) Zero hardness of softened water.
(2) High pH value of boiler feed.
(3) Uniform and accurate proportioning of phosphate to make-up, eliminating necessity of testing boiler concentrate for phosphate.
(4) Eliminates high pressure phosphate feeding equipment.
(5) As an adjunct to a cold or hot process softener it is applicable to all water supplies and produces a boiler feedwater unequalled in quality by any one individual water softening system.

Steam Engines

(Continued from p. 241)

costs for both large and small engines for one particular set of average conditions. Assume the following: 150 lb. steam pressure, no superheat, 5 lb. ga. back pressure, 2000 hr. operation per yr. with an average load 50 per cent of full load, all exhaust steam used, and steam costing 50 ct. per 1000 lb. Taking into consideration all operating and fixed costs, the cost of the by-product power would range from 0.75 ct. per b.hp. per hr. (1 cent per kw-hr.) in a small 12 hp. engine, to 0.3 ct. per b.hp. per hr. (0.4 ct. per kw-hr.) in a larger 225 hp. engine—an extremely low power cost. Note that these figures are based on an average load which is 50 per cent of full load. With the higher average load existing in many plants, these figures would be still lower.

It is not possible to give here complete water rate (steam rate) data for all sizes of steam engines but the chart Fig. 3 of an 8-inch stroke engine together with approximate corrections give an idea of the variations in the water rate for various conditions.

The modern steam engine is suitable for a wide range of steam conditions—20 to 400 lb. pressure, very wet steam to 750 deg. F. total temperature, vacuum to 75 lb. and higher back pressure. It is not damaged by the usual chemical impurities in steam.

(To be continued)

As One Engineer to Another—

Heating, Ventilating and Air Conditioning Show Starts Discussion of Principles Involved in Maintaining Healthful Atmospheric Conditions

By G. F. WETZEL

"DID YOU get a chance to go to the Heating, Ventilating and Air Conditioning show at the International Amphitheater, Chief?" I asked my friend the Chief Engineer, as we got together for another of our frequent chats.

"I'll say I was there. Look what I got," and he pointed to a substantial pile of catalogs and bulletins on the end of his desk. "By the time I get through all those, I ought to have a few more ideas on the subject. I have gone over the various kinds of equipment I saw, G. F., and have classified them alphabetically for my files. By the way, G. F., we hear so much about air conditioning from so many different angles, tell me just how you would describe it."

"Well, Chief," I answered, "in about nine cases out of ten when you hear the expression 'air conditioning,' if you will insert the word 'partial' it will be more accurate. To summarize what air conditioning means, it is the year-round control of indoor temperature, humidity, cleanness of the air, purity of the air, and air motion. None of these are new, but the combination of these treatments of the air is called 'air conditioning,' a term which has taken the public's fancy.

"To analyze further what air conditioning is, temperature control involves heating in the fall, winter and spring months, and cooling when necessary in the summer time. Heating of course, is not new, though a number of changes have been and are being made in the methods and equipment. Space cooling for comfort is a comparatively recent development as far as the wide application of it is concerned, though we have known how to do it for years. Space cooling in industry has been done longer, and space cooling for refrigeration has been used for many years.

"Year round temperature control requires an entirely different kind of equipment for summer cooling or winter heating, and either type may be installed independently of the other. You are quite familiar with heating equipment and know that stoves, gravity furnaces, forced warm air systems, hot water, vapor or steam may be used for residential heating, though in larger buildings, forced warm air, steam or vapor will be used. The forced air system is the only one that lends itself to both heating and cooling, and the air delivery must be very carefully designed to give satisfaction when used alternately for both functions.

"Humidity control, like temperature control, presents a different problem in winter from the summer job, because in summer we have from the right amount to a decided excess of humidity for comfort, and in the heating season, humidity must be added. You will remember that what we call humidity is nothing but very low pressure water vapor or steam, mixed with dry air, giving us so-called moist air. Adding humidity is comparatively simple, but removing humidity is a much more difficult and expensive process.

"Cleaning the air removes more or less completely, dusts, pollen, bacteria, and other non-gaseous, non-vapor particles. This naturally is a year-round function, and is done by one of the many types of air filters, or by passing the air through an air washer. A washer, by the way, may also be a humidifier, a dehumidifier and a heat exchanger."

"What do you mean, G. F., a washer may be a dehumidifier? Putting the air through a water spray will take out water?"

"That is right, Chief. Did you ever hear of saturated steam? Well, saturated vapor is the same thing as you well know. Suppose air goes into a washer at 80 deg. F. How much moisture could it hold if saturated? Look in your steam tables."

He reached for his book and after a moment answered, "If you mean the weight of one cubic foot of vapor at 80 deg., that would be 0.001,57 lb."

"All right, now if the air were cooled in the washer to 55 deg., saturated, how much vapor could it hold?" I continued.

He looked at his tables again and gave me a weight of 0.000,7 lb. per cubic foot.

"Does that tell you anything, Chief?" I asked. "Please notice that even though the air were only 50 per cent relative humidity at 80 deg. it would hold more moisture than saturated air at 55 deg. And air at 80 deg. and 50 per cent relative humidity ordinarily would not need dehumidifying. You will remember that when vapor is saturated the weight per cubic foot is absolutely the maximum that the space can hold under any conditions at the existing temperature and pressure. But we will discuss humidity again. Let's go back to our analysis of air conditioning.

"Purifying the air is merely a matter of ventilation, providing enough air from outside to keep the inside air sufficiently free from vitiation to be satisfactory, considering the requirements.

"Air motion is the result of introducing the heated or cooled air into the space to be conditioned, and control depends on the location and design of the delivery and return ducts, and the velocity of the air. The temperature of the incoming air affects to certain

extent the air motion, and very decidedly affects the comfort results. And that is air conditioning.

"Heating and ventilating practice is pretty well standardized, but air conditioning has so many variables that it is far from standard, and every job is an individual problem, with a number of ways of handling it, and degrees of completeness of conditioning. For heating, we figure on an inside temperature of 70 deg., usually, and an outside design temperature depending on the locality, and ignore humidity in our heat calculations, dealing with sensible heat only. Any heat gains from people, lights, motors or other sources, help to carry the load, and act to a certain extent as a safety factor.

Complete winter conditioning jobs do not need to allow for humidity or latent heat loads because the amount of heat involved is relatively small. The total heat loss is taken as the transmission losses, plus the sensible loss due to the air escaping from the building and carrying heat away, either because of infiltration or air introduced by a ventilating system, or both.

"A summer conditioning heat gain calculation has to take into account not only the heat transmitted into space through the walls, and the sensible heat of the air, but also the latent heat of the vapor introduced by all the incoming outside air, the latent heat of the moisture given off by the occupants, the sensible heat they give off, and all heat from lights, motors, appliances, etc., plus the sun effect if any."

"That sounds like a complicated process, G.F.," the Chief commented, "And just by way of review, tell me what you mean by sensible heat of the air, and what other kind of heat can air have?"

"You'll be surprised, Chief. Answering your second question first, air as used in air conditioning, has latent heat and total heat as well as sensible heat. Sensible heat is the heat which will change the temperature of 1 lb. of air 1 deg. F. for each 0.24 B.t.u. absorbed or given up as the case may be. It is this heat that is evaluated according to our old friend, the standard heat equation, which you will remember,

$$H = c\ W\ (t_1 - t_2)$$

where H is heat in B.t.u.
c is specific heat
w is weight in pounds
$(t_1 - t_2)$ is temperature difference"

"Yes, I remember that all right, but I thought air acted like a perfect gas and could not be liquefied at ordinary pressures and temperatures,—and if it can't be liquefied and evaporated, then there will be no change of state, and therefore no latent heat," the Chief argued.

"You are perfectly right, Chief. Latent heat of the air, so-called, is not latent heat of the air at all, but is the latent heat of the moisture mixed with the air, just another case of misleading nomenclature, and a matter of definition. The total heat of the air is taken as the sensible heat of 1 lb. of dry air above 0 deg. F. plus the latent heat of the vapor which is mixed with it, neglecting the small amount of the sensible heat of the water vapor. This may sound like a funny combination, but it works out very satisfactorily in practice and if you understand the basis, it is a very sensible and convenient way of working out the desired values.

"To see how it works out, go ahead and figure the total heat of saturated air at 70 deg. F. Remember you are dealing with one pound of dry air, mixed with saturated water vapor. Here is a table giving grains of moisture or vapor per pound of dry air. You can use you own steam tables for the correct latent heats. There are 7000 grains to a pound. Use 0.2415 for the specific heat of the air."

So he went to work and shortly showed me his paper:—

$H = 0.2415 \times 70$	$= 16.90$
Vapor per lb. air	$= 110.5$ grains
	$= 110.5 \div 7000$ lb. per lb. air
Latent heat per lb. vapor is 1052.7	
Latent heat 110.5 gr.	$= (110.5 \div 7000) \times 1052.7$
	$= 16.61$
Total heat	$= 16.90 + 16.61$
	$= 33.51$ B.t.u. at 70 deg. F.

"That is perfectly okay, Chief. You have remembered your basic principles in good shape. You can see from this that the total heat of the air involves nothing that is mysterious. The important point to keep in mind about the total heat of air is that the value itself does not mean anything in particular, but the difference in values for any two temperatures is what gives us our cooling load as far as the air is concerned, and also the total heat absorbing capacity of the air between the supply temperature and the room temperature."

"You say 'difference in temperatures', what temperatures do you mean?" the Chief asked.

"I'm glad you brought that up, Chief. There are three important temperatures we have to work with in air conditioning work, dry bulb temperature, wet bulb temperature, and dew point temperature, or dew point. Dry bulb temperature is the temperature we ordinarily read on the Fahrenheit thermometer. The wet bulb temperature as you probably remember is the temperature indicated by a thermometer with its bulb covered by a wet wicking or boot. The two thermometers, wet bulb and dry bulb, are mounted on a frame so that they can be swung around in a vertical plane, the air movement past the wetted boot causing evaporation, taking the latent heat of evaporation from the air and water and lowering the temperature. Naturally, the drier the air, the more evaporation there will be, and the lower will be the temperature.

"Swinging the dry bulb thermometer rapidly through the air or holding it in the draft from a fan will not have any effect on its reading. Therefore, the difference between the wet and dry bulb, temperatures is an indication of the relative humidity. The instrument made of two thermometers mounted so they can be swung around is called a sling psychrometer. If the wet bulb thermometer were not either swung through the air or held in a strong draft of air we would not get a true reading. The wet bulb temperature is called the 'temperature of adiabatic saturation', and is the lowest temperature that can be reached by evaporative cooling at atmospheric pressure for any given dry bulb temperature and relative humidity. And now to answer your question as to what temperature we use in finding the total heat: it is the wet bulb temperature, which is an extremely important temperature in air conditioning work."

Readers' Conference

Hypothenuse Determined by Slide Rule Method

FREQUENTLY engineers, especially electrical engineers, have occasion to perform the calculation of $\sqrt{a^2 + b^2}$, the algebraic expression for the hypothenuse of a right triangle. To do this one ordinarily squares the two quantities "a" and "b" on the slide rule, adds them, then resorts to his slide rule again to extract the square root to obtain the resultant. Very often it is necessary for the engineer to determine the resultants of a whole series of operations, a tiresome task of squaring and adding figures on a bit of scratch paper. A bit of algebraic juggling of the formula reveals a method by which the whole operation may be performed on the slide rule without having to do any intermediary addition to get the result, thus saving time, mental energy, scratch paper and your disposition. Here is how it is accomplished:

(1) $R = \sqrt{a^2 + b^2}$

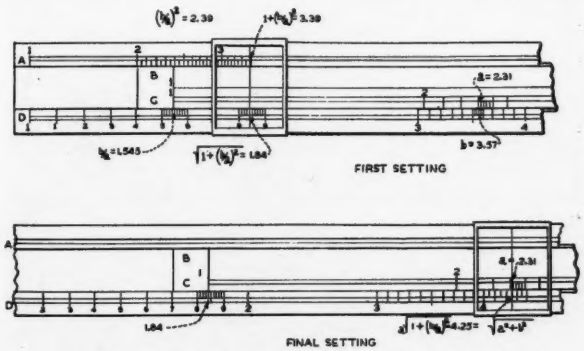
(2) $R = \sqrt{(a^2 + b^2) + \frac{a^2}{a^2}}$

(3) $R = \sqrt{\frac{a^4}{a^2} + \frac{a^2 b^2}{a^2}}$

(4) $R = \sqrt{a^2(1 + b^2/a_2)}$

(5) $R = a\sqrt{1 + (b/a)^2}$

It is readily seen from equation (5) that if the quotient of "b" over "a" is squared, added to unity,



Slide Rule Settings for Solving $R = \sqrt{a^2 + b^2}$

the root extracted and multiplied by "a" the answer will be "R" or $\sqrt{a^2 + b^2}$. These operations are easily performed on the slide rule in the following manner. A Mannheim slide rule will be referred to for simplicity in referring to the scales. Proceed as follows:

1. Set b/a on lower scales C and D.
2. $(b/a)^2$ is read on scale A with indicator in same position.
3. Move indicator to right so as to add 1.0 to $(b/a)^2$ as read on scale A.
4. With indicator in this position read $\sqrt{1 + (b/a)^2}$ on scale D.
5. Multiply this by "a" in the usual manner—result = R.

It is advantageous for "b" to be the larger number to avoid mental juggling of decimal values less than unity. You will note that from equation (5) that when "a" = "b":

$$R = \sqrt{2}\,a \text{ or } \sqrt{2}\,b$$

Below is a numerical example to illustrate more clearly the method employed:

Let a = 2.31

b = 3.57

(1) b/a = 1.545 from scales C and D.

(2) $(b/a)^2 = 1.545^2 = 2.39$—read on A scale without changing setting of indicator.

(3) Move indicator to 1 + 2.39, that is, $[1 + (b/a)^2]$ or 3.39 on scale A.

(4) Read square root of 3.39 on scale D.
$\sqrt{3.39} = \sqrt{1 + (b/a)^2} = 1.84$

(5) Multiply 1.84 by 2.31 = $a\sqrt{1 + (b/a)^2}$ = R = 4.25.

To check this figure

$$a^2 = 2.31^2 = 5.34$$
$$b^2 = 3.57^2 = 12.75$$
$$a^2 + b^2 = 18.09$$
$$\sqrt{a^2 + b^2} = \sqrt{18.09} = 4.25$$

Although five steps are indicated in the explanation, only 3 manipulations of the slide are required and no addition step is required. The entire operation is performed on the slide rule with no pencil additions on the side. The explanation may give the impression that the method is long, but the writer has found it to save considerable time with a minimum of mental fatigue.

New York, N. Y. M. A. SAYLAND

The CO_2 Recorder

No INVESTMENT in power-plant equipment, it is believed, will pay a higher rate of interest than a properly used CO_2 recorder. If this apparatus is to be intelligently used by the boiler operator, it is evident that he should keep himself informed as to the percentage of CO_2 the fuel burned will produce when just the correct amount of air is supplied for combustion. Given this factor, the maximum or ultimate Co_2, simple calculations, tables or graphs will supply the information needed to keep the combustion efficiency at a high point.

This ultimate CO_2 factor is usually calculated from combustion analyses of the fuel, or orsat tests of the products of combustion, or, it may be closely approximated from the readings from the recorder. Only gaseous fuels are considered below, yet liquid fuels are subject to similar relations. With a natural gas 86 per cent methane and 14 per cent ethane the calculated ultimate CO_2 is 12 per cent. In checking this result by an orsat analysis care should be taken to secure a sample that does not contain carbon monoxide, as the presence of this gas may indicate unburned gases other than the carbon monoxide itself. Calculation by this method is simple. For instance if an orsat test shows 10.0 per cent carbon dioxide and 3.5 per cent oxygen,

substituting these values in the following equation and solving gives 12.0 per cent as before.

Equation No. 1

$$\text{Ultimate } CO_2\ \% = \frac{20.91 \times \%\ CO_2 \text{ from orsat}}{20.91 - \%\ \ O_2 \text{ from orsat}}$$

In checking with the recorder for this ultimate CO_2 factor, it is assumed that the instrument is showing 10.0 per cent, that is, checking the orsat. If reducing the supply of air to the furnace causes this percentage to increase, it is evident that too much air is being used. Continue reducing the air supply until a drop in the reading of the recorder is noted. The highest percentage recorded will be near the correct ultimate CO_2 value.

The accompanying table is designed to aid in interpreting the readings of the CO_2 recorder when the gas is of the composition indicated. The table is based on the assumption that the hydrogen in the gas will burn to water vapor, as it usually does, and that a considerable percentage of carbon monoxide may be produced without a portion of the gas escaping unburned. This latter assumption will not as a rule hold in practice, as those who have tried firing an ordinary boiler with a reducing flame are well aware.

Referring to the table, it will be noted that when the recorder reading is 11.0 per cent, the flue gases may contain 1.74 per cent oxygen, or 1.23 per cent carbon monoxide. If a CO recorder were used in conjunction with the CO_2 instrument, or if an orsat test were made at this time we would know which side of the combustion equilibrium we were on. But as we are supposed to be firing without these "conveniences," the proper procedure is to try the air as suggested above, or the gas supply, in order to bring the CO_2 reading as near 12.0 per cent as possible. If this "ideal" percentage is not desired, the addition of air after this adjustment will reduce the reading to 11.0 or whatever percentage is desired. The operator now has the satisfaction of knowing that the fires are now on the oxygen side of the combustion equilibrium. However, it should be remembered that when the recorder is showing 12.0 per cent the amount of air or unburned gases leaving the stack is negligible.

Since modern furnaces will withstand the heat of the perfect combustion of natural gas, and since we have burner equipment which will produce such combustion, it would seem that the claim that 15 or 20 per cent excess air should be used in burning this fuel no longer holds. In support of this claim attention is called to an inert gas producer now being used in the industry, which generates a gas (from any gas suitable for domestic consumption) containing less than 1.0 per cent of oxygen and zero per cent carbon monoxide—practically pure nitrogen and carbon dioxide. This gas, it is claimed, may be inhaled in large volumes without irritation, so it must be free from hydrocarbons. The CO_2 content of this varied but 0.4 of 1 per cent in a three-day trial run.

Changes in the Percentages of the Volumes of Flue Gas for Varying Percentages of CO_2

CO_2 from Recorder Per cent	CO Per cent	O_2 Per cent	N_2 Per cent	Air Excess Per cent	Air Deficiency of Per cent
8.0	0.0	6.96	85.04	44.9	0.0
9.0	0.0	5.23	85.77	30.0	0.0
10.0	0.0	3.48	86.52	18.0	0.0
11.0	0.0	1.74	87.26	8.1	0.0
12.0	0.0	0.00	88.00	0.0	0.0
11.0	1.23	0.00	87.77	0.0	0.2
10.0	2.51	0.00	87.49	0.0	0.4
9.0	3.87	0.00	87.13	0.0	0.6
8.0	5.28	0.00	86.72	0.0	0.8

Gas burned 86.0 per cent CH_4; 14.0 per cent C_2H_6.

Experience leads to the following conclusions: That natural gas may be burned most economically when the percentage of CO_2 on the recorder is kept as near the ultimate CO_2 value as possible; that gaseous fuels may be burned practically without excess air, that is 5 per cent or less; that the use of the CO_2 reading from the recorder in formulas designed to calculate the percentage of excess air may lead to erroneous results as shown by the table.

Sugar Grove, O. HENRY COONEY.

Fuel Oil Tanks—Correction

THERE IS evidently an error in the interesting and informative article on Fuel Oil Tanks in the February issue. On page 106 the author describes a method of computing the buoyant effect of ground water in the case of an underground tank installation. In arriving at the "maximum flotation" value, the volume of the submerged portion of the tank below ground water level is deducted from the volume of water which the excavation would contain below the level of the ground water.

The fallacy of deducting this volume of the tank is more apparent if a tank of rectangular dimensions is considered. If the excavation were the same size as the tank, there would be no buoyant effect, even though the tank were of negligible weight and entirely empty, according to the method described in the article.

Hartford, Conn. LLOYD J. PORTER.

I MOST certainly owe readers an apology for the obvious error which appeared in my article on Fuel Oil Tanks, and I thank Mr. Porter for calling attention to it.

The capacity of the tank should not, of course, be deducted from the estimated maximum amount of water which might be contained in the excavation, but if the cubic content of the tank with that of the concrete pad, be deducted from the volume of the excavation based upon the area of the pad, it will give the cubic feet of earth which can be loaded on the tank and pad to aid them in counterbalancing the weight of water which they, together with the earth, are assumed to displace, and which they must displace, if they are to be safe against flotation.

JAMES O. G. GIBBONS.

Wasting of Boiler Plates

IT WILL sometimes be found that when a steam blast is used for soot blowing, wastage of the boiler plates occurs where the steam first impinges on them. One of the great causes of this sort of trouble is where the boiler water contains a high percentage of impurities and there is a steam leak past the soot blower stop cock. The leaking steam will carry solid impurities which accumulate in the steam pipe.

Although the amount of impurities which will accumulate will be very small, and in some cases may be almost non-existent, those which are deposited will be carried away with the steam blast when next used and act as an abrasive on the plates. When con-

tinued for long periods serious wasting may occur due to this effect. The valves of these blows should be kept tight so that steam leakage does not occur.

Kent, England. W. E. WARNER.

Needle for Oiling

AS ENGINEER in a sanatorium, I think I have something worth telling other readers of Power Plant Engineering.

An old hypodermic syringe makes one of the nicest "utility" oil cans that I have found. The oil can be forced out exactly as desired: one or any number of drops. For the spout, an old "pneumothorax" needle serves about the best. Although this is extremely smaller than practically any oil-can spout, it is large enough for using even steam cylinder oil, and is long enough to serve many quite inaccessible places (about 3 in.).

Jackson, Mich. ARTHUR CHURCHILL.

Flow Meter Detects Faults

WHEN IT was decided to install meters on the steam lines supplying paper machines and auxiliaries at a certain paper mill located in Canada, it was done with the idea that better cost records could be obtained and also better operating conditions. The meter which was installed on the line supplying a steam turbine which drove one of the paper machines not only gave the information desired, but went a few steps further, turned detective, and pointed out an improper pipe layout. Correction in this single incident made possible savings which more than paid for every meter installed in the place.

There had always been trouble on this particular paper machine due to an unaccountable variation in the speed which resulted in a product which was not uniform. Various remedies had been tried and an expert examination of the steam turbine and the machine itself failed to discover anything wrong. After the meter had been installed on the supply line to the turbine it was noticed that there was a considerable variation in the steam flow which in turn varied the speed of the turbine. This typical variation in flow is shown on the accompanying chart record between 8.45 a.m. and 8.10 p.m.

One of the staff in observing the action of the meter pen for some time finally noticed that the dips were in synchronism with the dumping of a large trap. The trap was taking steam from the same line which supplied the turbine at a point not far from the nozzle. When the trap dumped it momentarily took steam away from the turbine line, caused a slight drop in pressure, and a consequent variation in speed. The remedy was simple once the trouble had been spotted. A by-pass line was run so that steam for the traps could be taken from an entirely different line which could have no effect on the turbine line. When this by-pass line was cut in (8:15 p.m. on the chart) a decided difference in the flow was immediately noticed. The fluctuations were cut down to a minimum and no further trouble was had due to variation in speed of the paper machine.

Sayreville, N. J. K. B. HUMPHREY.

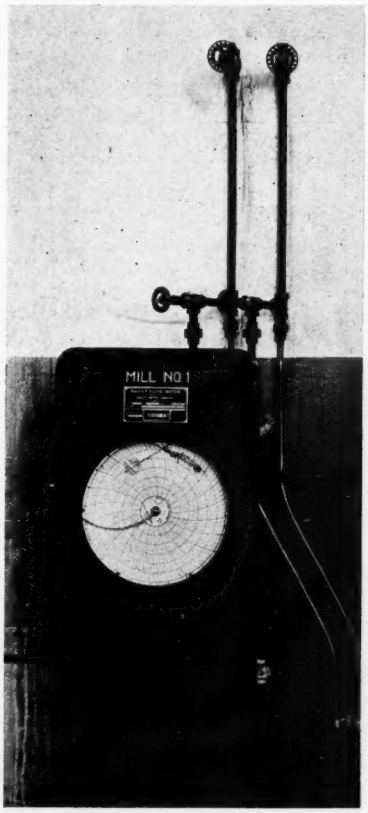


Fig. 1. Steam flow meter on line to paper machine

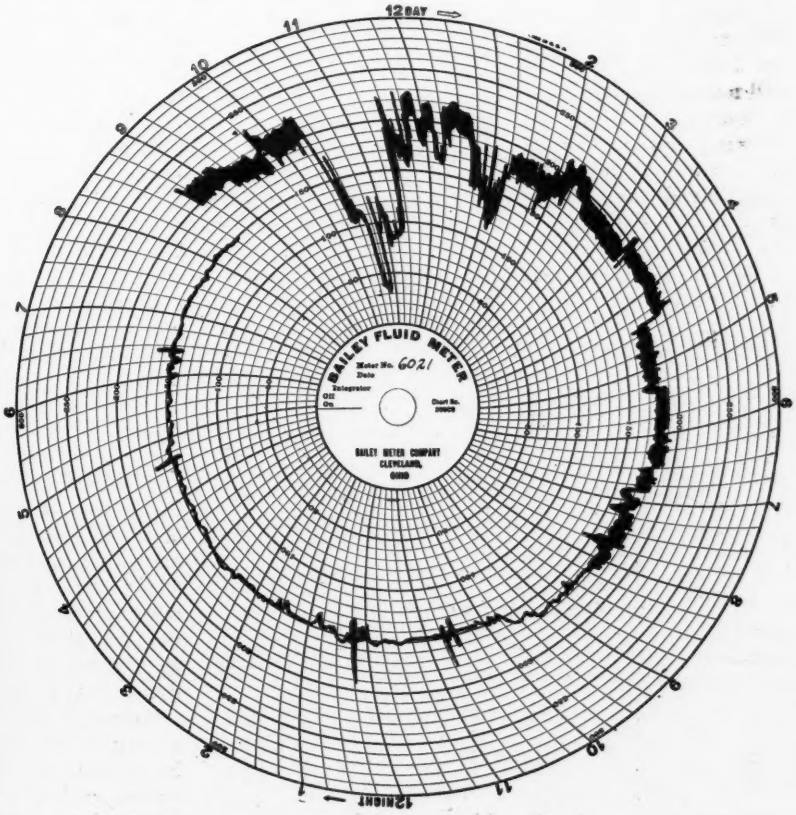


Fig. 2. Flow meter record showing effect of change in trip connection

Reduced Vs. Extracted Steam

Q. If high pressure steam at 450 lb. gage pressure, 730 deg. F. total temperature, is reduced to 100 lb. gage, 365 deg. F. and desuperheated by water at a temperature of 230 deg. F., how many pounds of water are used for desuperheating 100,000 lb. of steam? Does all this water turn to steam at the lower pressure and temperature? What is the loss in B.t.u.'s for reducing and desuperheating? D. K.

A. Superheated steam at 450 lb. gage, 730 deg. F. has a total heat content of 1375.7 B.t.u. per lb. While superheated steam at 100 lb. gage, 365 deg. F. has a total heat of only 1202.2 B.t.u. per lb. This represents a total heat drop of 173.5 B.t.u. per lb. of steam. Water at 230 deg. F. has a heat content of 368.14 B.t.u. per lb. and to turn this water into steam at 100 lb. gage, 360 deg. F. would require the addition of 834.06 B.t.u. per pound of water. That means that each pound of water evaporated would absorb the heat from (834.06 ÷ 173.5 or) 4.81 lb. of steam. 100,000 lb. of desuperheated steam would therefore require 100,000 ÷ 4.81, or 20,800 lb. of water. This water would of course be evaporated to steam and the resulting product would total 120,800 lb.

Water injected into superheated steam in this way will eventually be entirely evaporated. The speed with which this takes place depends upon the turbulence and velocity of the steam as well as the fineness of and atomization of the water and other factors which are of course dependent upon the design of the desuperheater and valve.

If we neglect the loss due to radiation from the reducing and desuperheating valve, there is no heat loss as passing steam through a reducing valve causes no thermal loss while desuperheating is simply a transfer of heat from one medium to another and entails no loss. The reduction in pressure does, however, change the entropy of steam or the capacity of the steam for doing work. For instance, each pound of 450 lb., 730 deg. F. steam if expanded to atmospheric pressure adiabatically has a potential energy output of 307 B.t.u. per pound, whereas 100 lb., 360 deg. steam has a potential energy output of but 152.2 B.t.u. per lb. if expanded to the same pressure. If we multiply 152.2 by the factor 1.208 to take care of the total quantity of steam after the desuperheating water is added, we get a total of 184 B.t.u. potential energy for each pound of steam, through the reducing valve. The potential loss of work, not heat, is therefore the equivalent of 307 minus 184 or 123 B.t.u. or about 95,600 ft. lb. of work per pound of steam.

Q. At certain loads on a turbine steam can be bled at 40 lb. gage, 385 deg. F. If 35 lb. of this steam used in the turbine will generate 1 kw-hr., what is the possible saving by using this bled steam rather than 100 lb. gage, 360 deg. F. steam for the process work? The 100 lb. steam would have to be reduced from 450 lb. gage, 730 deg. F.

A. It is difficult to answer this question without making some assumptions, not only as to the origin of the 100 lb. steam, but as to its use as well. If we assume that the 100 lb. steam was reduced in the reducing valve and desuperheater combination mentioned in the question above, and that, total heat not high temperature is the major requirement for the process work, calculations may be made with a fair degree of accuracy.

For instance, 40 lb. steam at 385 deg. F. has a heat content of 1226.1 B.t.u. per lb. while 100 lb., 360 deg. steam has a heat content of but 1202.2 B.t.u. per lb. We have seen, however, that each pound of steam reduced from 450 lb., 735 deg. F. and then desuperheated, furnishes a total of 1.208 lb. of steam at 100 lb., 360 deg. F. due to the additional desuperheating water. Therefore each pound of reduced steam would have a final heat content of 1202.2 times 1.208 or 1452 B.t.u. To supply 1452 B.t.u. in bled steam would require 1452 ÷ 1226 or 1.185 lb.

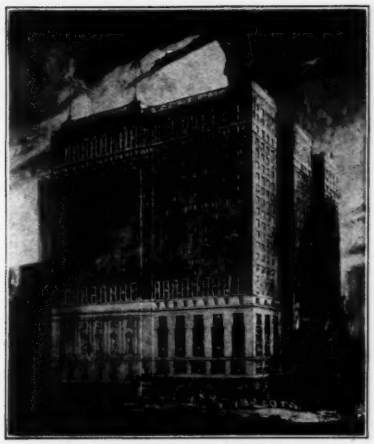
In other words, if 1000 lb. of 100 lb. steam (reduced and desuperheated from 450 lb., 735 deg. F.) is required for a certain process, the same process would require 1185 lb. of 40 lb. extracted steam. If each 35 lb. of extracted steam coming through the turbine will generate 1 kw., 1185 lb. would generate 33.7 kw. and the loss, or the potential loss, due to using live steam rather than extracted steam is equal to the value of 33.7 kw. per thousand pounds of 450 lb., 730 deg. steam used for process.

The above calculations do not take account of the amount of heat carried away in the condensate. For instance, if the condensate in both cases was cooled to a temperature of, say, 232 deg. F., the available heat in the extracted steam would be reduced to 1026 B.t.u. per lb. and in the 100 lb. steam to 1002 B.t.u. per lb. This reduces slightly the difference between the extracted and reduced steam, although the reduction would be negligible.

If the temperature of the condensate was reduced only to the saturation temperature of the steam in each case, the net heating value of the steam would be reduced to 970 B.t.u. per lb. for the 40 lb. steam and to 892 B.t.u. per lb. for the 100 lb. steam. With these values, about 1110 lb. of extracted steam would be equivalent to 1000 lb. of 450 lb. steam (reduced and desuperheated). This would mean a reduction in kilowatts to about 31.5 per thousand pounds.

Based on the steam flow to the reducing valve, pound for pound, the heat value of the reduced steam is more valuable than the extracted steam and has the advantage of a 50 degree higher saturation temperature. This difference in heat is accounted for by conversion to electrical power. The higher temperature would give better heat transmission through a given heat transfer surface but has the disadvantage of the loss of the potential power as calculated above roughly 32 kw. hr. per 1000 lb. If this power had to be purchased at 1 cent per kw. hr. its value would be approximately equal to that of the steam. In other words, neglecting fixed charges, the power would pay for the steam and still leave it practically unchanged for power use. Proper division of charges between power and process in this case is a complicated and highly controversial subject. It was discussed at considerable length by Linn Helander in the article Distribution of Energy Charges in Industrial Plants which appeared in the October and November 1934 issues of Power Plant Engineering.

Midwest Power and Engineering Conference



Palmer House, Chicago

Cooperating Engineering Societies to Present Program of Broad Interest to Utilities and Industries Generating and Using Power in All Its Phases

WITH SEVEN different engineering societies cooperating in the preparation and presentation of the program planned for the Midwest Power Engineering Conference, all phases of engineering which have to do with the generation and use of power will be considered in Chicago during the four day meeting, April 20 to 23.

The Conference will hold its opening session at 10:30 a. m. April 20 in the Palmer House, Chicago, with an address by Frank D. Chase, President of the Power Conference Board, who will outline the purpose and objectives to be accomplished by the Conference. As an industrial engineer Mr. Chase has had an opportunity to observe the phenominal increase in the use of mechanical and electrical power during the past generation and his observations on present opportunities for improving power conditions will be of distinct value.

The afternoon session on Monday will take up problems in power economics and will be presided over by A. A. Potter, Dean of Engineering at Purdue University and President of the American Engineering Council. "Trends in Research" is the subject of a paper to be delivered by Dr. C. F. Hirshfeld of the Detroit Edison Co., whose activities in this field have done much to advance the efficient and economical generation of power. "Interchange of Power and Steam Between Industries and Public Utilities" is the subject under which Wm. A. Hanley of Eli Lilly & Co., Indianapolis, Ind., will present his experiences in this arrangement of obtaining power and steam.

Tuesday Devoted to Civils, Electricals and Diesels

Power Plant Buildings and Dams is the general topic for a session at 9:30 a. m. Tuesday. At this session P. E. Stevens, design engineer of the Byllesby Engineering & Management Corp., will deliver a paper entitled "The Influence of Earthquakes on Power Plant Design." The second paper for this session will describe Fort Peck Dam and will be presented by Claude H. Chorpening, Corps of Engineers, U. S. Army, Assistant to District Engineer at Fort Peck, Mont.

Another session to be held at this same time, arranged by the American Institute of Electrical Engineers, will have for its chairman Wm. Sims, Chief Electrical Eng., Commonwealth Edison Co. At this session F. H. Farmer, of Westinghouse Electric & Mfg. Co., will present a paper entitled "Recent Turbine Generator Developments" and J. D. Wright, of General Electric Co., will discuss "Outstanding Applications of Electric Power to Industry."

A simultaneous session for Tuesday morning will be devoted to Diesel and Internal Combustion Engine Power with A. C. Kirkwood of Burns and McDonald, Kansas City, Mo., as chairman. This will open with a film entitled "Romance and Progress of the Diesel Engine," shown through the courtesy of the Hemphill Diesel School. "Heavy Duty Portable Diesel Engines for Construction and Contracting" is the title of a paper to be presented by G. E. Spain of the Caterpillar Tractor Co., Peoria, Ill. "Large Diesel Engine Mechanical Developments" will be the subject of a paper by Max Rotter, Vice President in Charge of Engineering, Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo., and the third paper of the session will be on "Present Day Diesel Fuels," by T. M. Robie, Fairbanks, Morse & Co., Chicago.

Full Day Program Planned for Wednesday

Three simultaneous sessions are scheduled for Wednesday morning; that on Refrigeration will be conducted under the chairmanship of L. S. Morse, National President A. S. R. E., with a paper on Air Conditioning Application by Messrs. Zieber and Nicoll, both of the York Ice Machine Corp., York, Pa., and a second paper entitled "Refrigerants" by Harry D. Edwards, Consulting Engineer of Carbide & Carbon Chemical Corp., New York City.

A session on Fuels—Classification of Coals by Use Value—over which Stuyvesant Peabody, President Peabody Coal Co., Chicago, will preside, is scheduled for this period with a paper on "Use Value of Coal for Steam Generation" by John Nash, Chief Engineer, Bendix Corp., of South Bend, Ind.; another, "Some Characteristics of Midwest Coals" by H. L. Olin of Iowa State College, and a third, "Simplification of Coal Sizing," by Joseph Harrington, Combustion Engineer, Chicago. Discussions dealing with these papers will cover the use of oil and gas as well as coal.

Power Piping and Welding will be considered in another session on Wednesday morning, with E. P. Rich of Neiler, Rich & Co. as chairman. A paper on "Valves" by H. H. MacMillen of the Milwaukee Electric Railway & Light Co., another, "Power Plant Piping," by J. Roy Tanner of the Pittsburgh Valve, Foundry & Construction Co., Pittsburgh, Pa., and a third, "Welding of Alloy Steels and Pipe," by J. R. Dawson of the Union Carbide & Carbon Research Laboratories, Niagara Falls, N. Y., have been scheduled for presentation at this session.

For the afternoon meeting on Wednesday, a discussion of unusual importance and general interest is being arranged to deal with Engineering Economics in the National Power Picture. F. F. Fowle, President of the Western Society of Engineers, will preside at this session and will present the first paper under the title "Engineering Criteria of Power Supply." A government representative will then present "The Nation's Power Supply:—Its Economic Development under Government Participation," which will be followed by an engineer affiliated with private industry, presenting "The Nation's Power Supply:—Its Economic Development under Private Enterprise." The speakers will be announced later, and it is planned to leave plenty of time for discussion from the floor.

Plant Equipment and Fuels

Thursday will be another day filled with sessions devoted to strictly power engineering topics. The session on Power Plant Technics in the morning will be conducted under the chairmanship of A. D. Bailey, Chief Engineer of the Commonwealth Edison Co., Chicago, and three papers are scheduled for presentation and discussion. "Trend of Large High Pressure High Temperature Boiler Design" is the subject of the paper to be presented by F. H. Rosencrants of Combustion Engineering Co. Dr. R. E. Hall, Hall Laboratories, Pittsburgh, Pa., will present a paper on "Water Conditioning for High Pressure Steam Generation." Another paper, the author of which will be announced later, will deal with turbine operation and application.

A session dealing with Fuels and Furnaces will be conducted under the chairmanship of E. H. Tenney, Chief Engineer of Power Plants of the Union Electric Light and Power Co., St. Louis, Mo. At this session, M. K. Drewry of the Milwaukee Electric Railway and Light Co. will present a paper on "The Value of Proper Furnace Equipment to Power Plant Economy," and John C. Kuhns of the Staley Mfg. Co., Decatur, Ill., will discuss "What Modern Fuel Burning Equipment Means to the Industrial Plant."

Power Transmission to Machinery is the general heading for another session on Thursday morning, at which G. C. Miller, Vice President of the Dodge Mfg. Co., Mishawaka, Ind., will preside. A paper on Modern Group Drives will be presented by W. R. Clendenning, Engineer for the Power-Transmission Council. "Load Acceleration and Overload Release" will be discussed by Wm. Stanier of E. I. Du Pont de Nemours, Inc., and "Direct Motor Drives for Machinery Application" will be treated in a paper by F. E. Butterfield of the Commonwealth Edison Co., Chicago.

The final technical session of the Conference will be held Thursday afternoon and will be devoted to Fuel Economy and Controls, conducted under the chairmanship of M. L. Enger, Dean and Director, College of Engineering and Engineering Experiment Station, University of Illinois. A paper by A. F. Spitzglass and G. K. O'Connor, both of the Republic Flow Meters Co., Chicago, will deal with "Coördinating the Operation of Boiler Auxiliaries"; another by Frank Clark of Stone & Webster Engineering Corp., Boston, will treat the subject, "Super-imposing of High Pressures on Existing Plants"; and the third paper will be presented by a speaker from the Federal Housing Administration and deal with the subject, "Modernizing Old Plants."

In addition to the technical program, a banquet will be held at the Palmer House on Wednesday evening and several groups of engineers are planning luncheons for different days of the week.

Frank D. Chase, President of Conference

The Midwest Power Engineering Conference is a cooperative enterprise participated in by the American Institute of Electrical Engineers, the Chicago Section of the American Society of Mechanical Engineers, the Edison Electric Institute, the National Safety Council, the Western Society of Engineers, the American Society of Civil Engineers and the American Society of Refrigerating Engineers. Membership in the Council, however, is not confined to members of engineering societies, but entails registration, the cost of which is one dollar and entitles members to all benefits of the Conference.

Officers of the Conference are as follows: Frank D. Chase, President, Chicago; Oscar A. Anderson, Vice-President, Engineering Division, Armour & Co.; Paul Doty, Past President of A. S. M. E., St. Paul, Minn.; Wm. A. Hanley, Eli Lilly Co., Indianapolis, Ind.; J. H. Hunt, General Motors Co., Detroit, Mich.; E. H. Tenney, Union Electric Light & Power Co., St. Louis, Mo.; W. M. White, Allis-Chalmers Co., Milwaukee, Wis.; G. E. Pfisterer, Secretary, 308 W. Washington St., Chicago, Ill.; K. A. Anty, Treasurer.

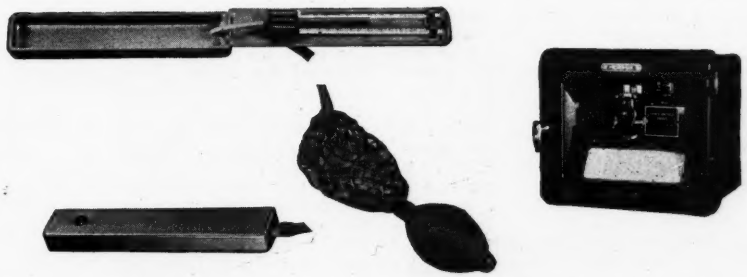
New Equipment

Friez Psychrometer

JULIEN P. FRIEZ & SONS, INC., Baltimore, Md., announce a new hand-aspirated psychrometer. Wet and dry bulbs of this psychrometer are aspirated by means of induced air blown across the bulbs at uniform high velocity to give adequate ventilation. It is said to eliminate the irregular results sometimes experienced with the common sling psychrometer due to inexperience and inconsistencies in the length of time the instrument is whirled.

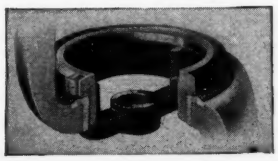
Speed Recorders

SPEED can be continuously indicated and recorded at any desired location, regardless of distance from the rotating member, by means of Micromax Speed Recorders, Leeds & Northrup Co., 4900 Stenton Ave., Philadelphia, Pa. A heavy-duty tachometer magneto, attached to the rotating shaft, generates an electromotive force, proportional to speed, which is carried by ordinary leadwires to a Micromax Recorder of the type preferred. Recorder immediately indicates it for the guidance of operator; records it on a moving chart for both operator and management. Recorder can, if desired, also actuate signals or any type of warning device or automatic control.



Secoweld

SECOWELD is the name given to a new method of sealing the valve seat into the body of the valve. Instead of welding the seat ring into the body, a separate ring of Seco metal is welded in, and that in turn threaded to take the regular Seco metal seat ring. As this metal can resist the wiredrawing action of the steam, in case a slight leak occurs it will not damage the threads, and if necessary the seat ring can be taken out, cleaned and jammed back tight.

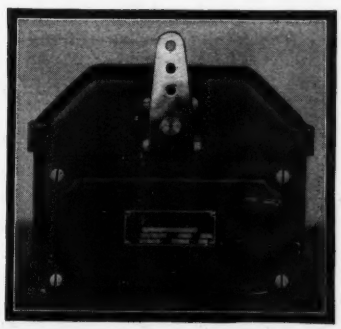


This design has been devised to overcome the inherent weakness in the joint between the seat ring and the body, due largely to the difference in quality of metals used in the seat and the body. Secoweld is the product of Spence Engineering Co., Inc., Walden, N. Y.

INGERSOLL-RAND CO., Phillipsburg, N. J., announces the Channel Valve, a recent development for air and gas compressors. The moving parts of the valve consist of the valve channels within each of which is a flat spring. The spring fits snugly in the channel so that when the valves lift the springs straighten and a small quantity of air trapped between the springs and channel form air cushions. The operation of the valve is shown effectively by a cellophane insert in a new booklet, "The Channel Valve."

Valve Controller

DEMAND for industrial furnace temperature control with minimum disturbances to furnace atmosphere has resulted in development by Automatic Temperature Control Co., Philadelphia, Pa., of two new types of multi-position controllers known as the Relatrol and the Balancer. Both units produce a corrective movement in a valve or damper in relation to departure from the temperature setting, as measured by the actuating instrument. In external appearance both units are alike. A special relay is supplied, wired into the circuit between the actuating instrument and the motor mechanism. This relay embodies an electrically controlled null-point and as full line voltage is used in both relay and power motor, extra responsiveness is secured to repositioning demand. The mechanism is housed in a sturdy, compact, cast-iron case which will withstand the rough usage of industrial service.



The balancer is similar to the Relatrol except that it is provided with automatic means of load compensation and is recommended where load changes will be of considerable extent and duration. The new Relatrol action employed by these mechanisms can be used in conjunction with many standard pyrometers, flow meters and other measuring instruments, by slightly modifying the contact mechanism.

Both units are equipped with a 110 v. a. c. motor, have a maximum stroke of 4 in. (time for full stroke 60 sec.) and develop a pull of 75 lb. at the end of the operating lever.

Compressed Air Dryer

RUEMELIN MFG. CO., 3860 N. Palmer St., Milwaukee, Wis., announce a compact compressed air drying system which consists of: a contra-flow after-cooler; an expeller to remove the condensed water and oil from the cooled air; and an automatic drain trap which drains the accumulated moisture and oil from both the after cooler and expeller. Cooling the air removes the heat caused by compression, and the moisture, which is carried in the form of vapor, is precipitated and then expelled from the air by the centrifugal action of the expeller. The drying system is made in a variety of sizes or from 40 up to 300 c.f.m.

Grinder Supports

IN ADDITION to the types of supports regularly furnished with Ideal Precision Commutator and Slip Ring Grinders, announcement is made of several new types of supports that greatly simplify their use and broaden their application.

These new supports, "O.E.", "T.O.", "W", "Universal" and "Plate" Types are of entirely new design, and make it possible to use Ideal Grinders on practically any type of machine. In cases where standard brackets and this new line of supports are not applicable, by slight modification in design and construction, one of the existing supports can be used.

Of particular interest is the new "O.E." Type support. This support is attached to the motor so that the grinding tool with its resurfacing element is mounted on a rigid and inflexible base, in the right position and high enough for non-obstructed and easy operation, and where the work is done in full view of the operator.

The "T.O." Type is designed for attaching to the brush yoke and bearing pedestal. The "W" Type is used for mounting Ideal Grinders on the larger exciters, motors and generators. This support attaches to the main frame of the machine. The "Universal" Type attaches to the main housing and the bearing support. The support designated as the "Plate" Type is for the smaller units and attached to the end bell of the motor.

This new series of Ideal Precision Grinder Supports gives wider adaptability, allows for better performance, truer and faster work. They are made by Ideal Commutator Dresser Co., Sycamore, Illinois.

Remote Control

To SUPPLEMENT automatic control systems, the Foxboro Co., Foxboro, Mass., developed recently the new remote hand control. The Foxboro Remote Hand Control mounted on a centrally-located panel enables the operator to adjust manually the degree of opening of an out-of-the-way, inaccessible valve without moving from his station. With it, he can reset a valve several hundred feet away to control temperature, pressure, flow or liquid level using readings from his recording instruments to

guide him in making the correct adjustments.

Extreme precision of valve setting makes easy change in pressure on the diaphragm motor of the controlled valve as small as ¼ in. of water or less. This means that the valve opening can be altered by as little as a few thousandths of an inch to produce the exact desired flow of controlled medium. Used in conjunction with a Stabilflo valve, the controlled flow can be changed by less than 1 per cent.

Special Transformer

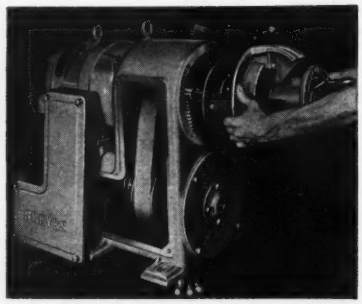
A NEW TRANSFORMER has been developed by The Acme Electric & Manufacturing Company of Cleveland for the purpose of increasing the safety factor in inspection or maintenance service. This unit is particularly designed for use in plants or in service where inspection or maintenance must be done with electric illumination and in moist or damp places in buildings permeated with explosive vapor or fumes. Likewise, the use of this unit around any machinery, boilers, tanks, etc., reduces the potential shock or explosive hazards.

The Acme Safety Transformer is a compact, portable unit. A primary cord, rubber covered and Underwriters approved may be plugged into any 110 v. 60 cycle circuit. The two secondaries to which extension cables are attached, each consist of vulcanized approved cable with special non-pull-out-plugs. An ordinary pull on the extension will not break the circuit. Secondary potential is rated at 32 v.

Reeves Motodrive

REEVES PULLEY Co., Columbus, Ind., has developed the Reeves Vari-Speed Motodrive, which combines in a compact, self-contained enclosure any standard make of constant speed motor, variable speed control mechanism and (where required) speed reduction gears.

Any make of foot type, constant speed motor, within standard NEMA dimensions, may be used. Speed variation as provided by the Motodrive is infinite between predetermined limits. Merely by turning a convenient handwheel, any desired speed within the range is made smoothly and quickly available to insure maximum operating efficiency of the driven machine. A convenient dial indicator registers speeds on a scale calibrated from 1 to 6.



The Motodrive utilizes the proved mechanical principle of a V-belt running between two sets of cone-faced disks which are adjustable in diameter and mounted on parallel shafts. One shaft receives power at constant speed from the motor and the other shaft transmits power at infinitely adjustable speeds to any driven machine.

The drive is available in two compact designs—horizontal and vertical. Each design is built in four sizes which take motors from ¼ to 7½ hp. capacities and which cover speed ratios from 2:1 through 6:1. Reduction units of helical gear type in ratios up to and including 189:1 may be incorporated in the drive. In different combinations of sizes, ratios and reduction gears, output speeds ranging from a minimum of 1.35 r.p.m. to a maximum of 3480 r.p.m. may be obtained.

A. S. T. M. Meeting

AS THE RESULT of a large number of meetings of A.S.T.M. standing committees, held in Pittsburgh during Committee Week, March 2-6, many new standard specifications and methods of test are to be recommended to the Society. In all there were about 150 meetings, including main standing committees, their sections and subcommittees. The total registered attendance for the group meetings was about 625, exceeding that of any previous year.

Five papers comprising the Symposium on High-Strength Constructional Metals was the technical feature of the meeting. Two sessions, morning and afternoon, were devoted to the papers and discussion. These papers included: Alloys of Aluminum and Magnesium by E. H. Dix, Jr., and J. J. Bowman; Alloys of Copper by C. H. Davis; Alloys of Nickel by G. F. Geiger; Carbon and Low-Alloy Steels by E. F. Cone; and Corrosion-Resisting Steels by E. E. Thum. The published symposium will serve a most useful purpose in bringing together in one convenient place the latest information on the physical and mettallurgical properties, etc., of the constructional and higher strength alloys developed in recent years.

A progress report was presented covering the coöperative studies on the part of the committee on Metallography and the Fatigue committee involving X-ray diffraction studies and their relation to fatigue test results. While no clear correlation has as yet been shown, the study is progressing. It was indicated that long-time tests are necessary to enable definite conclusions to be drawn. There was also discussion of the progress made in the study of the effects of occasional high overstress on subsequent resistance to repeated working stresses and reports of work in this study were submitted from several laboratories. New types of testing machines for fatigue tests were described. These new machines include high-speed machines (10,000 cycles of stress per minute), machines for repeated loading of large specimens of full size structural and machine parts, and machines for testing wire under reversed stresses.

Methods of detecting fatigue cracks when still small using magnetized iron dust, etching and direct microscopic examination were brought up and differences in reporting results of fatigue tests by English laboratories and by American laboratories were indicated. Minor matters noted were fatigue cracks under repeated compression, and metals showing unusually high ratio between fatigue strength and ordinary tensile strength.

Considerable data were presented by the Committee on Coal and Coke concerning check determinations of coal ash fusibility by the Barrett coal-ash fusion furnace and by the gas furnace specified in the A.S.T.M. requirements. These data proved to be sufficiently promising, in the opinion of the committee, to justify further investigation with a view to acceptance of this new furnace as permissible equipment in the standard method of test. It was agreed not to revise at this time the present tentative methods for determination of grindability of coal. Investigations are in progress which will probably lead to later revisions of these methods.

Gratifying progress was reported in the development of methods of testing friability of coal, that is, its resistance to breakage on handling. Two methods are under consideration, one is a drop test method similar to the shatter test method for coal. By this method a large sample can be used. The other is a tumbler jar method adaptable for testing samples of 1000 g. in weight, which makes use of equipment now available in most coal testing laboratories. The methods under consideration have been published by the Canada Department of Mines, Publication No. 762 (1935).

Progress was reported in the formulation of a mechanical method for crushing and reducing gross samples of coal to a convenient size for transmittal to the laboratory. Such mechanical methods of reduction of coal samples are coming into general use by large consumers of coal since the standard hand method is expensive due to the large amount of manual labor in-

volved. The mechanical method of reduction is rapid and is thought to be less liable to personal errors. Some additional work remains to be done before this mechanical method of reducing coal samples can be recommended to the Society.

A proposed method for determination of dustiness of coal and coke was presented for discussion by a subcommittee. Dedusting of coal and coke is increasing rapidly. In connection with the rapid development of small domestic stokers which burn the smaller sizes of coal, it is desirable to dedust the coal so the householder will have a clean fuel. A test method will be of help in evaluating the efficiency of different oil compounds and chemicals used for dedusting.

The Committee on Water for Industrial Uses approved release of, for publication as information only, methods of analysis of four ions, the carbonate, hydroxide, phosphate, and sulfate. The methods have been edited so that they can be applied to water used generally in industry.

Groups working on methods of analysis has under active discussion development of methods for the determination of chlorides, calcium and magnesium. Additional work of this group includes the further development of the dissolved oxygen method. In addition, methods of analysis are to be developed covering sodium ion and silica and the determination of the hydrogen ion concentration.

This committee and the Joint Research Committee on Boiler Feed Water Studies will jointly sponsor a session at the 1936 A.S.T.M. annual meeting at Atlantic City in June on water for industrial uses, including several important papers of interest in this field. Subjects it is planned to discuss include the following: rate of reaction of anhydrous sodium sulfite on dissolved oxygen, interpretations of studies on the cracking of steel, the use of solubility data to control the deposition of sodium sulfate, the effect of sodium sulfate and other salts on the action between sodium hydroxide-sodium silicate solutions and steel, and the determination of oxygen in boiler water.

Hodgkinson Retires

THE RETIREMENT of Francis Hodgkinson from the employ of the Westinghouse Electric and Mfg. Co. was marked recently with a dinner given in his honor by the employees of the company's South Philadelphia Works, at the Racquet Club in Philadelphia. Co-worker with Sir Charles Parsons and later right hand man of George Westinghouse in the development of the steam turbine in the United States, Mr. Hodgkinson leaves Westinghouse Company after 42 yr. of outstanding service to that company and to the engineering profession.

Francis Hodgkinson was born on June 16, 1867, at London, England. Educated in the Royal Naval School, New Cross, England, he was apprenticed in 1882 to Clayton and Shuttleworth Agricultural Engineers, Lincoln, England. In 1885 he became associated with Sir Charles Parsons in the early development of the reaction steam turbine. In 1890 his services were requested by the Chilean Navy, which organization he joined and served during the revolution of that time. From 1892 to 1894 he was engaged in work for the Telephone and Electric Light Co. of Lima, Peru, and in connection with mining properties at Casapalca, Peru.

In 1894 he rejoined C. A. Parsons and Company, becoming superintendent of the erecting and fitting shops. In 1896 when George Westinghouse negotiated a license agreement with Sir Charles Parsons, Mr. Hodgkinson, at the latter's recommendation, came to the Westinghouse Machine Co. to initiate the designing and construction of steam turbines. He was responsible for steam turbine construction until 1916, when he was made Chief Engineer, responsible for all steam power apparatus of the Westinghouse Electric and Mfg. Co.

In 1926 he was made Consulting Mechanical Engineer for the Westinghouse Co., which position he has held until the time of his retirement. During this period he has been the principal U. S. delegate to the International Electro-Technical Commission.

News from the Field

GEORGE CHRISTEN has been chosen to manage the new Crosby Steam Gage & Valve Co., Inc., of California, the formation of which has been announced in a recent statement. The new company, with offices, shops and warehouses at 2034 Santa Fe Avenue, Los Angeles, will maintain a

complete stock of Crosby products. Shop facilities have been established for the repair and service of all types and makes of safety and relief valves and pressure gages.

JOHN C. PAGE, Chief of the Engineering Division of the Bureau of Reclamation, has been appointed Acting Commissioner of Reclamation. Mr. Page was born at Syracuse, Nebraska, October 12, 1887. He graduated in 1908 from the University of Nebraska with a degree of Bachelor of Science in Civil Engineering, and continued his education at Cornell University in the study of Hydraulics and Civil Engineering for 18 months.

He first entered the Reclamation service October 1, 1909, as a topographer in the location of canals in Colorado, then left it briefly to serve as city engineer for Grand Junction, Colorado. On July 1, 1911, Mr. Page reentered the service and assisted in the construction of the Grand Valley Project. Since that time he has been in the Bureau continuously.

Mr. Page became Superintendent of the Grand Valley Project in 1925, and was transferred to Nevada as Office Engineer of the Boulder Canyon Project September 12, 1930, a position of large administrative responsibility which he held until October 1, 1935, when the late Dr. Mead selected him for chief of the engineering division of the Commissioner's office.

RAYMOND DILL, treasurer of Allis-Chalmers Mfg. Co., died suddenly of a heart attack in his office on March 17. Mr. Dill was born fifty-five years ago on a farm near Dayton, O., and graduated in 1901 in electrical engineering at Ohio State University. His first connection was with Westinghouse Electric Company. In 1905 he joined the Allis-Chalmers organization, at the Bullock Works in Cincinnati and in 1908 was transferred to the Electrical Division in Milwaukee. In 1923, he was elected treasurer of the company, and later secretary and treasurer.

PROVISIONAL PROGRAMS and application cards for the Seventh International Congress of Refrigeration to be held in Holland, June, 1936, are available and may be obtained from the headquarters of the organization, 107 Stolberglaan, The Hague, Holland.

THE LINCOLN ELECTRIC CO., Cleveland, Ohio, has moved its Pittsburgh office, formerly at 323 Fourth Ave., to larger quarters at 926 Manchester Blvd.

THE INTERNATIONAL NICKEL CO., INC., has appointed as its representatives in the Chicago area, H. L. Geiger, 333 North Michigan Ave. Bldg., Chicago, Ill., and on the west coast, A. G. Zima, Petroleum Securities Bldg., Olympic and Flower Sts., Los Angeles, Calif.

ANNOUNCEMENT has been made of the formation of Harold Van Doren and Associates, industrial designers of Toledo, Ohio, to supersede the firm of Van Doren and Rideout which was recently dissolved after a three year partnership. Included with Mr. Van Doren as associates are Robert C. Deiggert, Edna Remmert, W. F. Brecht, and R. K. Knoblaugh.

MOORE STEAM TURBINE CORP. has recently appointed L. R. Merritt & Co., 250 Park Ave., New York City, as sales representative in the metropolitan area. A. F. Reinking will be retained as direct factory representative. Another appointment is that of Evans L. Shuff, 686 Greenwood Ave., Atlanta, Ga., who will represent the corporation in the states of Alabama, Georgia and eastern Tennessee.

THE DAMPNEY CO. of America has opened a branch office at 220 Bagley Ave., Detroit, Mich., which will be in charge of C. M. Boling, formerly resident engineer of the company at Cleveland, Ohio.

GEORGE P. SCHUMACKER, for the last 15 yr. associated with The Worthington Pump & Machinery Corp., has established an office in Cleveland, Ohio, 1120 Chester Avenue, representing The Cooling Tower Co., Inc., The Pennsylvania Pump & Compressor Co., Quincy Compressor Co., The National Steam Pump Co., The Stets Co., The V. D. Anderson Co., The Williams

Valve Co., The Sea-Ro Packing Co. and The Mabbs Hydraulic Packing Co. These companies manufacture cooling towers, spray ponds, heat exchangers, compressors, air lifts, dry vacuum pumps, centrifugal pumps, turbine pumps, power pumps, rotary pumps, boiler feedwater and liquid level regulators, boiler water alarm columns, steam traps, special valves, check valves, foot valves, pump valves and packing.

PLANS ARE being made by G. H. Porter, Managing Director of the Oil Burner Institute, for the National Oil Burner Show to be held April 14 to 18 inclusive in Detroit, Mich. The Show will be thoroughly comprehensive in its scope, taking in the new field of air conditioning in connection with oil appliances and public attention will be called to the place held by oil fuel in this market.

THE 1935 LAMME MEDAL of the American Institute of Electrical Engineers has been awarded to Dr. Vannever Bush, Vice-President of the Massachusetts Institute of Technology, and Dean of the School of Engineering, "for his development of methods and devices for application of mathematical analysis to problems of electrical engineering." The medal and certificate will be presented to him at the annual Summer Convention of the Institute, which is to be held in Pasadena, California, June 22-26, 1936.

H. M. BYLLESBY & Co. reports improvements in earnings and financial condition for the year 1935. John J. O'Brien, president, points out that profit from trading and underwriting of securities and interest, dividends, etc., less selling and other expenses, interest, taxes, etc., amounted to $228,816.38 for the year as compared with a deficit on the same basis of $16,326.58 for the year ended December 31, 1934, and that the surplus account of the company as of December 31, 1935, amounted to $1,800,241.45 as compared with $834,049.93 on December 31, 1934.

For the Engineer's Library

A. S. H. & V. E. GUIDE, 1936. Published by the American Society of Heating & Ventilating Engineers, 51 Madison Ave., New York, N. Y. Size 6 by 9 in., flexible cloth binding, 792 pp. Price $5.00.

In the 14th edition of The Guide a large amount of new and revised data have been assembled on the subjects of heating, ventilating and air conditioning increasing the contents of the Technical Data Section to 792 pages. Four new chapters have been added to fulfill the requests for more detailed information on the subjects of Refrigeration, Drying, Electric Motors and Railway Air Conditioning.

In addition to the new material which has been added, the previous chapters have been checked and reviewed and in some cases the text has been completely rewritten so as to conform to more recent engineering practices.

In addition a catalog section of 254 pages plus the index brings the total volume up to 1900 pp. The 254 pages of Catalog Data include descriptive matter on the products of leading manufacturers and is a valuable adjunct to the Technical Data Section as it provides a ready reference section for material and equipment selections.

A. S. T. M. PROCEEDINGS, 1935. Published in two parts by the American Society for Testing Materials, 260 So. Broad St., Philadelphia, Pa. Size 6 by 9 in. Part I, 1488 pp.; Part II, 769 pp. Price each volume $5.50 paper bound; $6.00 cloth bound; $7.00 half leather.

Part I contains the reports of 40 standing committees as well as 136 tentative specifications either recently published or revised in 1935. These include standards for ferrous metals, non-ferrous metals, cement, brick, clay pipe, refractories and concrete as well as preservative coatings, petroleum products, waterproofing materials, electrical insulation, etc. Appended sections involve problems in standardizing methods of sampling water, microscopic method of particle-size measurement and statistical methods of analysis and presentation of data.

Part II contains 37 technical papers presented during the 1935 annual meeting, extensive written and oral discussion and the Marburg Lecture on aircraft materials and testing. Spectrographic analysis of metals, engine design and volatility on oil consumption, soil resistance and wear tests are but some of the subjects covered by the papers.

DIESEL OPERATING GUIDE. By Julius Rosbloom. Published by Diesel Engineering Institute, 443 Hoboken Ave., Jersey City. Size 5½ by 7 in., 532 pp., flexible cover. Price $5.

This is primarily an instruction book for the Diesel operator showing by simple language and illustrations the principles of operation and design of various type engines. Operating directions, general auxiliaries and accessories, electrical equipment, maintenance pointers and miscellaneous tables and methods of calculation broadens the scope of the book. Several portions of the book are presented in questions and answers form to assist those interested in home study, for, says the author, "the operation of Diesel engines and their auxiliaries is not learned in a brief time. It is a long drawn out process and requires a clear insight of the mechanism and a general understanding of their principles."

CAMERON MOTORPUMPS for condensate return service are described and illustrated in the eight page booklet No. 1972-A of the Ingersoll-Rand Co. The unit consists of a receiver, Cameron Motorpump, suitable automatic starting and stopping devices. It is used for condensate return in department stores, school buildings, etc.

FLEXROCK Co., 800 N. Delaware Ave., Philadelphia, Pa., is distributing a new four page folder describing Longlife, an elastic, flexible, rubbery, plastic material made of asphalt and used for roofing, caulking, glazing flashings, acidproofing and waterproofing.

FUEL ENGINEERING Co. of New York, 116 East 18th St., New York City, has recently published a pamphlet entitled Steam Plants Geared into Fuel Markets which is the story of the service this company renders to fuel burning plants, dealing particularly in the work of fuel-engineering resources and experience to a certain class of problems relating to economy in steam generation.

A NEW BOOK, No. 1725, has been published by Link-Belt Company, Indianapolis, on Silverstreak silent chain drives obtainable from stocks carried at the company's warehouses and by authorized distributors located in important business centers. This stock group includes drives of ½ to 60 horse power.

THE CHAIN BELT Co., Milwaukee, Wis., has issued a pamphlet featuring Rex spray nozzles, a non-clogging device used for spraying and cleaning various kinds of products in the course of manufacturing or producing operations. It is interestingly illustrated with photographs to show the drive and force of the fan-shaped spray.

"A RUBBER PLANTATION in New Jersey" is the title of a book published by the Thiokol Corp., Yorkville, N. J., that presents in brief fashion the developments up to the present in the utilization of synthetic rubber by American industry. The book is non-technical and gives much information about synthetic rubber—and Thiokol, the trade name for a leading synthetic rubber. Thiokol is now used in automobiles, in filling stations, in the press rooms of newspapers and in airplanes. Thiokol stands up under gasoline, oil, sunlight and ozone.

COMBUSTION ENGINEERING Co., 200 Madison Avenue, New York, is distributing an attractively illustrated catalog on the CE-Heine box header boiler. This boiler was first brought out in 1882 and the first unit of this type is now on exhibition in the Ford Industrial Museum at Dearborn, Mich. Besides descriptive matter and numerous photographs of boiler details and typical finished installations, there are included drawings of ten different setting arrangements as adapted to various fuels and methods of firing. Views of shop equipment for annealing and X-raying the drums are also shown.

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., is distributing a bulletin designated as No. 1261 dealing with the simple variable speed device known as the Vari-Pitch Texrope Sheaves. The bulletin illustrates not only the stationary controlled type but also the motion controlled type together with the company's new straightline automatic ball bearing motor base permitting complete adjustment while in operation.

ELEMENTS OF DIESEL ENGINEERING. By Orville Adams. Published by The Norman W. Henley Publishing Co., 2 W. 45 Street, New York City. Size 6 by 9 in., 451 pp., cloth bound. Price $4.

Perhaps best described by the introduction—"an easily understood introductory manual for the student, mechanic, operator and practical engineer, suitable for home or school use." As such, the book covers various types of engines from their earliest development through to modern types including European and high speed models. There is a great deal of information on maintenance and operation and for home study purposes questions and answers at the end of many chapters adds to its value.

PURPOSES AND REGULATIONS of the Air Hygiene Foundation of America, Inc., Thackeray Ave. and O'Hara St., Pittsburgh, Pa., are included in Information Circular No. 1 just issued by the Foundation which was organized for the purpose of conducting investigations of, and to stimulate research on, problems in the field of air hygiene.

THERMOSPEED, a new separable well tube system for thermometers and temperature controllers and with a rate of response closely approaching that of the fast Taylor bare tube systems, is announced by the Taylor Instrument Cos., Rochester, N. Y., in an 8 page folder, Form 99019.

THE HAYNES STELLITE CO., Kokomo, Ind., has published a new 8-page booklet "Haynes Stellited Valves," which cites the increased life and economy resulting from the application of Haynes Stellite to the seating surfaces of valves for use in high temperature, high pressure steam service.

VERTICAL TURBINE PUMPS for deep well and similar service are described in an eight-page bulletin recently issued by the Worthington Pump & Machine Corp., Harrison, N. J.

PUMPS of all kinds for industrial and general service are described in a new 118 page catalog issued by Goulds Pumps, Inc., Seneca Falls, N. Y. The back part of the catalog contains 5 pages of hydraulic data.

EDWARD BLOWOFF VALVES are made the subject of Catalog No. 11-D by the Edward Valve & Mfg. Co., East Chicago, Ind. The catalog contains descriptions of four series of blowoff valves, in Ferac metal, cast steel and forged steel, both straightway and angle types and contains many illustrations of actual installations and optional piping arrangements.

BULLETIN No. 2448 of the Illinois Testing Laboratories, Inc., 141 W. Austin Ave., Chicago, describes in detail the "Alnor" Velometer for the instantaneous direct reading of air velocities. Two ranges are provided: a low range from 0 to 250 or 300, which provides accurate velocity readings for as low as 20 f.p.m.; and a high range, which will give correct readings as high as 6,000 f.p.m. Special ranges can also be supplied.

A BOOKLET DESCRIBING SOME of the outstanding recent waterwheel generator installations and giving data on hydro developments and various forms of generator construction has recently been published by the Westinghouse Electric & Manufacturing Company. This 24-p. publication includes installation views of many stations together with construction diagrams of several generators such as for Boulder Dam, Norris Dam, Conowingo. Also, typical construction diagrams include engine type horizontal, medium size umbrella type, medium size vertical, bracket bearing horizontal and pedestal bearing horizontal generators. A list of large installations with their ratings are also contained in this interesting booklet.

POWER TRANSFORMERS is the subject of a new 32-page booklet recently issued by the Westinghouse Electric & Manufacturing Company. It describes performance characteristics, insulation coordination, core and coil construction, cooling, painting, condenser bushing features, auxiliary devices, and testing facilities.

AMERICA & LUBRICATING GREASES is the title of a bulletin recently issued by the Virginia Polytechnic Institute and prepared by James I. Clower, Assistant Professor of Machine Design. This bulletin deals with the manufacture of greases, tests and their significance, greases for lubrication versus oil, methods of application, specifications, and concludes with a bibliography citing the reader to numerous books, bulletins and articles dealing with the subject of lubricating greases. A valuable insert giving the classification, composition and uses of greases is also included making the bulletin a comprehensive treatment of the subject.

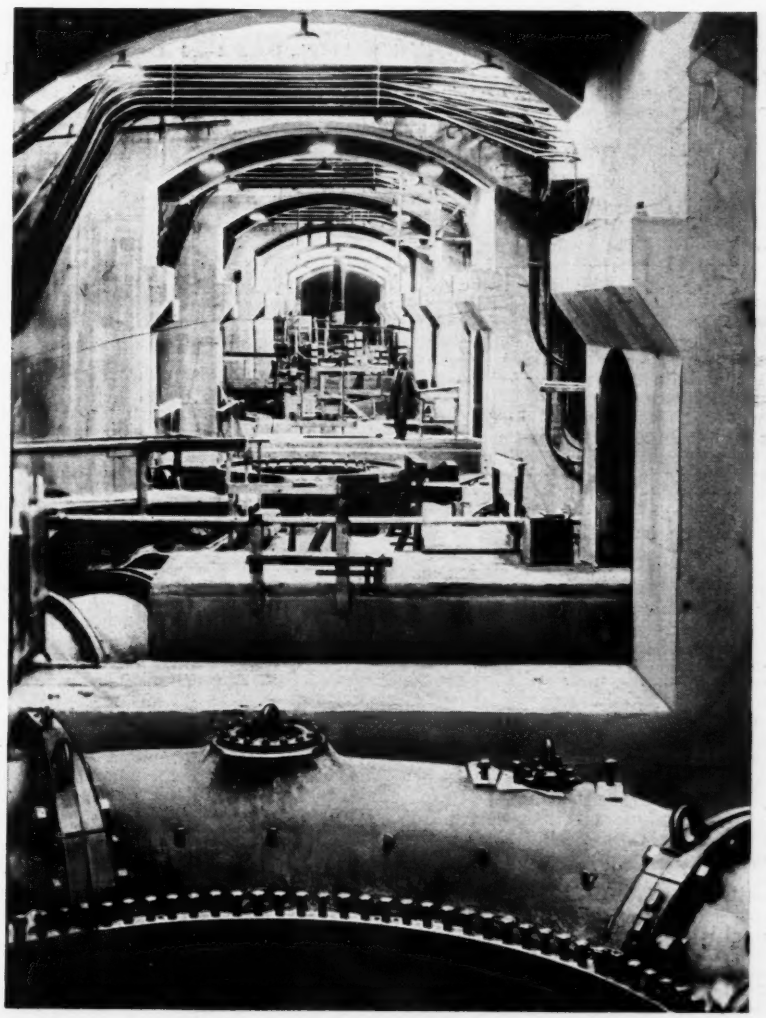
WAGNER ELECTRIC CORP. has prepared a new bulletin No. SD549 on the subject of "Service Instructions for Capacitor-Start Induction-Run Motors" for the use of manufacturers of motor-driven appliances and their service organizations.

The bulletin lists the troubles most frequently encountered, and should, therefore, help service organizations in solving the great majority of their motor troubles. The subject has been prepared in outline form in order to make it a simple matter to spot the type of problem encountered and obtain immediate solution.

INVESTIGATION of the use of gaseous fuel in warm-air furnaces is the title of research bulletin No. 48 published by the Engineering Experiment Station, Purdue University, Lafayette, Ind. It is the result of studies made by R. B. Leckie, professor of gas engineering, and is a continuation of the work reported in research bulletin No. 36 which dealt with the use of gas in domestic steam boilers. Tests show that gas conversion in boilers designed for solid fuel give as high or higher efficiency than boilers built expressly for gas.

YOUR NEW PLANT: Multi-story or Single Story—Which? is an engineering study by The Austin Co., Cleveland, Ohio, made for the purpose of guiding industrial executives and determining the character of the plant best suited to their needs and which will be conducive to the lowest possible operating cost and require the minimum building investment.

THE LINDE AIR PRODUCTS CO., 30 East 42nd Street, New York, in a booklet "How to Bronze-Weld," summarizes the available information on bronze-welding and bronze-surfacing. This is a practical presentation of the fundamental theory and technique of bronze-welding and bronze-surfacing. The advantages of speed and economy are brought out, and also the ability of bronze-welding to accomplish jobs which otherwise might be difficult or impossible such as the joining of dissimilar metals.



Boulder Dam Turbines

A recent view at the Boulder Dam Power Plant showing the casings of the 115,000 hp. hydraulic turbines installed in the pits. Photo, courtesy Allis Chalmers Co.

Power Plant Construction News

Ala., Brewton—Common Council plans early call for bids for new butane air-gas plant for municipal service, including gas distributing lines. Financing has been arranged through Federal aid. R. L. Keenan Co., Montgomery, Ala., is consulting engineer.

Calif., Duarte—Duarte Foothill Citrus Association, Fish Canyon Road, plans installation of electric power equipment conveyors and other mechanical-handling equipment in new one-story fruit-packing plant, to replace a unit destroyed by fire a few weeks ago. Entire project will cost about $65,000. R. M. Finlayson, 108 East Colorado Boulevard, Monrovia, Calif., is architect.

Calif., Long Beach—Spencer Kellogg & Sons, Niagara Square, Buffalo, N. Y., manufacturers of linseed oil and kindred products, have plans for a one-story steam power house in connection with new branch plant at Long Beach, where tract of land was recently acquired. Electric power equipment will be installed for operations in refinery and other main plant units. Entire project will cost over $150,000. William J. Moran, 1011 South Fremont Street, Alhambra, Calif., is engineer, in charge.

Calif., San Diego—Consolidated Aircraft Corporation plans installation of electric power equipment in new one-story additions to airplane manufacturing works, 100x450 ft., 50x200 ft., and smaller. Entire project will cost over $100,000. Edward C. and Ellis W. Taylor, 803 West Third Street, Los Angeles, are architects and engineers.

Colo., Denver—Omaha Flour Mills Co., W. O. W. Building, Omaha, Neb., plans installation of electric power equipment in new flour mill and grain elevator at Denver. Entire project will cost over $450,000. Horner & Wyatt, Board of Trade Building, Kansas City, Mo., are consulting engineers.

Conn., Bridgeport—United Illuminating Co., 128 Temple Street, New Haven, Conn., plans extensions and improvements in steam-electric generating plant at Steele Point, Bridgeport, including installation of new equipment. Work will be carried out in connection with 1936 expansion program to cost close to $2,000,000, including transmission and distributing lines in rural areas.

Ga., Atlanta—Southern Waxed Paper Co., Woodrow Avenue, S. W., plans installation of electric power equipment in new addition to plant for manufacture of processed papers. Cost about $75,000. Proposed to begin work soon. Benjamin Lacy is general manager.

Ill., South Chicago—Republic Steel Corporation, Republic Building, Cleveland, Ohio, plans installation of electric power equipment in new multi-unit wire mill on Eighteenth Street, South Chicago. Cost close to $1,000,000. Company engineering department is in charge.

Iowa, Rock Rapids—At recent special election, citizens have approved bond issue to make total fund of about $200,000, including financing through Federal aid, for proposed municipal electric light and power plant. Proposed to begin work in spring. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Mass., Cambridge—Dewey & Almy Chemical Co., Harvey Street, plans installation of electric power equipment in new multi-story plant addition. Entire project reported to cost about $125,000. H. L. Kennedy is company engineer.

Mass., Canton—Draper Brothers Co., manufacturer of leather specialties, has plans under way for new addition to power house on Draper Lane, including improvements in present plant and installation of new equipment. Cost estimated close to $50,000. Arthur L. Nelson Engineers, 31 St. James Avenue, Boston, Mass., are consulting engineers.

Mich., Detroit—Fanny Farmer Candy Shops, Inc., 7 Griffith Street, Rochester, N. Y., plans installation of electric power equipment, refrigerating machinery and other mechanical equipment in new four-story manufacturing plant at Detroit. Cost close to $250,000.

Mo., Mountain Grove—Common Council has preliminary plans under way for new municipal electric light and power plant. Proposed to arrange bond issue for project at early date. Estimates of cost now being made. C. N. Garrison, Sprinfigeld, Mo., is consulting engineer.

Neb., Omaha—Armour & Co., Union Stock Yards, Chicago, Ill., plans installation of electric power equipment in new addition to meat-packing plant at Thirtieth and Q Streets, Omaha. Cost over $400,000. Proposed to begin work soon. F. A. Linberg, Chicago office noted, is company engineer.

N. Y., Rochester—Rochester Gas & Electric Corporation, 89 East Avenue, Rochester, has plans maturing for new steam-electric generating plant to duplicate in capacity a similar station, recently completed. It will cost over $1,000,000 with turbo-generators and auxiliary equipment. Proposed to begin work in the spring.

N. D., Fargo—Northern States Power Co., Minneapolis, Minn., plans installation of new mechanical stokers and auxiliary equipment in power plant at Fargo. Company will also make improvements in steam generating plant at Minot, N. D., with installation of new boiler unit, stokers and accessories. Work will be carried out in connection with 1936 expansion and improvement program.

Ohio, Ashland—City Council is considering new municipal electric light and power plant, estimated to cost close to $1,000,000, including electrical distributing lines and power substation facilities. Barstow & Lefeber, Inc., 31 North Jackson Street, Akron, Ohio, is consulting engineer.

Ohio, Bergholz—Louise Coal Co., Bergholz, plans installation of electric power equipment in connection with proposed rebuilding of tipple and conveyor units at local coal-mining properties, recently destroyed by fire. Loss close to $50,000.

Ohio, Dayton—Construction Service, Veterans' Administration, Washington, D. C., will receive bids until April 14 for new boilers, stokers and auxiliary steam power plant equipment for installation in power station of institution at Dayton.

Ohio, Montpelier—Board of Public Affairs plans extensions in municipal electric light and power plant, including installation of a new turbo-generator unit and accessory equipment. Cost estimated close to $50,000. C. O. Smith is chairman of board.

Ohio, Wapakoneta—Common Council has plans maturing for new municipal electric light and power plant, with distributing lines, estimated to cost close to $175,000. Proposed to begin work in the spring. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ohio, Youngstown—Cold Metal Process Co., manufacturer of rolling mill machinery, plans installation of electric power equipment in connection with rebuilding of plant, recently destroyed by fire. Loss close to $500,000, including machinery. V. J. Lamb is president.

Ore., Freewater—Utah Canning Co., Ogden, Utah, plans installation of electric power equipment in new branch food products canning and packing plant at Freewater, where site has been selected. A steam power house will be built for processing service. Entire project will cost close to $100,000. Work is scheduled to begin soon.

Pa., Fleetwood—Borough Council has plans maturing for new municipal electric light and power plant, and will begin work on project in near future. Fund of $166,000 has been arranged through Federal aid. J. W. Maskell, 947 East Rittenhouse Street, Philadelphia, Pa., is consulting engineer.

Tenn, Memphis—Globe-Union Mfg. Co., East Keefe Avenue, Milwaukee, Wis., plans installation of electric power equipment in new branch plant, 120x200 ft., on Mallory Riverside Boulevard, Memphis, for storage battery manufacture. Entire project will cost about $65.000.

Texas, Houston—Ferris Brick Company, Ferris, Texas, plans installation of electric power equipment in new plant on tract of about 35 acres of land in vicinity of Houston, to develop initial capacity of 40,000 brick per day. Entire plant will be electric-operated. Cost about $70,000.

Va., Jewell Ridge—Jewell Ridge Coal Corporation, Jewell Ridge, plans installation of electric power equipment in connection with new tipple at coal-mining properties, including conveying and other mechanical-handling equipment. Entire project will cost over $75,000. Allen & Garcia Co., 332 South Michigan Avenue, Chicago, Ill., is consulting engineer.

W. Va., Fairmont—Reilly Tar & Chemical Co., plans installation of electric power equipment in connection with extensions and improvements in plant. Entire project will cost close to $100,000. George F. Kucera is general manager.

Wis., Crandon—Gambill Distilling Co., Green Bay, Wis., care of Foeller, Schrober & Berners, 310 Pine Street, Green Bay, architects, plans installation of electric power equipment in new distillery in vicinity of Crandon. Entire project will cost over $80,000. Architects noted are in charge.

Wis., Milwaukee—Froedtert Grain & Malting Co., South Thirty-eighth and West Grant Streets, plans installation of power equipment, conveying, cleaning and other mechanical equipment in new addition to grain elevators. Cost about $350,000. Proposed to begin work late in April. K. R. Froedtert is president in charge.